

FY 2013 Federal Agency Climate Change Adaptation Plans: Summary of Research and Information Needs

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About the USGCRP Adaptation Science Interagency Working Group

In 2009, the Obama Administration convened an Interagency Climate Change Adaptation Task Force (ICCATF)¹ with the participation of more than 20 Federal agencies. Shortly thereafter, President Obama signed *Executive Order 13514: Federal Leadership in Environmental, Energy, and Economic Performance*,² directing the ICCATF to recommend ways the Federal Government can strengthen the Nation's ability to adapt to the impacts of climate change. Several Workgroups were established under the ICCATF including one on Adaptation Science. This Work Group was soon transferred to the U.S. Global Change Research Program (USGCRP)³ in 2010 in recognition of USGCRP's mission for advancing the research of global change and making research products available and translated to support and inform adaptation actions. The mission of the USGCRP Adaptation Science Interagency Workgroup (ASIWG)⁴ works to ensure that Federal science effectively informs adaptation decisions at a range of scales, in diverse sectors. It also provides scientific support to agencies in the adaptation planning process. For more information on the USGCRP Adaptation Science efforts, see: <http://globalchange.gov/what-we-do/prepare-the-nation-for-change>

¹ White House Council on Environmental Quality. *Task Force Progress Reports*. Website: <http://www.whitehouse.gov/administration/eop/ceq/initiatives/resilience>

² White House. *Executive Order 13514: Federal Leadership in Environmental, Energy, and Economic Performance*. Federal Register Vol. 74, No. 194. October 2009. Website: <http://www.gpo.gov/fdsys/pkg/FR-2009-10-08/pdf/E9-24518.pdf>

³ U.S. Global Change Research Program. *About*. Website: <http://globalchange.gov/about>

⁴ U.S. Global Change Research Program. *Prepare the Nation for Change*. Website: <http://globalchange.gov/what-we-do/assess-the-us-climate>

Executive Summary

1. Introduction

In June 2013, President Obama announced his comprehensive plan for steady, responsible action to cut carbon pollution, prepare the Nation for the impacts of climate change, and lead international efforts to address climate change as a global challenge. The Plan builds on significant progress made during the Administration's first term on all of these fronts, including those based on the ongoing scientific work of USGCRP's 13 member-agencies, the Interagency Climate Change Adaptation Task Force in which USGCRP participates, and USGCRP's National Climate Assessment team (see Box 1).⁵ The President's plan contains a full section on the critical need to prepare for the impacts of a changing climate that are already being felt across the country, including by "ensuring that Federal operations and facilities continue to protect and serve citizens in a changing climate."

In addition to its impacts on communities, public health, businesses, ecosystems, and a range of economic sectors, climate change poses an array of potential challenges and opportunities for Federal Government operations, programs, services, and assets.⁶ Abrupt and gradual climate-related changes in sea level, permafrost thawing, extreme precipitation, intense heat waves, sea ice melt, ocean acidification, water scarcity, and an increase in the frequency and severity of climate change-influenced natural disasters are among the risks that the Federal Government needs to consider in order to continue meeting its missions for the Nation in future. Given the impacts the Nation is already experiencing, and the projected changes in climate; we now face the reality mitigation measures alone will not minimize the Nation's risks to changes in the climate; we must also prepare for and respond to these changes in the climate. Climate change adaptation is a critical step towards ensuring the resilience of the Nation's built infrastructure, natural resources, and human populations.

In June 2012, the Federal Government took a major step forward by requiring, for the first time, that individual agencies produce Climate Change Adaptation Plans. Under the implementation guidance of *Executive Order 13514 - Federal Leadership in Environmental, Energy, and Economic Performance*, each Federal agency was required to include a climate change adaptation and action plan as an appendix to its annual Strategic Sustainability Performance Plan. In these plans, agencies were asked to: (1) develop a high-level vulnerability analysis; (2) identify appropriate adaptation actions; and (3) develop an implementation plan for fiscal year 2013 (FY13). The plans were intended to help agencies identify actions to reduce and manage the harmful effects climate change and take advantage of new opportunities that climate change may bring, primarily as related to agency missions.⁷ Agencies consulted a number of resources as they compiled adaptation plans, and the U.S. Global Change Research Program (USGCRP) was cited uniformly as one of the best resources for climate science and climate change information to support the development of agency adaptation plans and actions.

Box 1. Remarks by the President on Climate Change

"We have a moral obligation to leave our children a planet that's not polluted or damaged, and by taking an all-of-the-above approach to develop homegrown energy and steady, responsible steps to cut carbon pollution, we can protect our kids' health and begin to slow the effects of climate change so we leave a cleaner, more stable environment for future generations."

- June 25, 2013, Georgetown University, Washington, DC

⁵ The White House Council on Environmental Quality. *Progress Report of the Interagency Climate Change Adaptation Task Force: Recommended Actions in Support of a National Climate Change Adaptation Strategy*. 2010: p. 6. Website: <http://www.whitehouse.gov/sites/default/files/microsites/ceq/Interagency-Climate-Change-Adaptation-Progress-Report.pdf>

⁶ The White House Council on Environmental Quality. *Progress Report of the Interagency Climate Change Adaptation Task Force: Recommended Actions in Support of a National Climate Change Adaptation Strategy*. 2010: p. 8. Website: <http://www.whitehouse.gov/sites/default/files/microsites/ceq/Interagency-Climate-Change-Adaptation-Progress-Report.pdf>

⁷ The White House Council on Environmental Quality. *Progress Report of the Interagency Climate Change Adaptation Task Force: Federal Actions for a Climate Resilient Nation*. 2011: p. iv. Website: http://www.whitehouse.gov/sites/default/files/microsites/ceq/2011_adaptation_progress_report.pdf

Following submission of the FY13 Agency Climate Change Adaptation Plans, the Office of Management and Budget (OMB) and the Council on Environmental Quality (CEQ) reviewed each plan (June 2012 - January 2013) and then released the plans to the public⁸ (February 2013), beginning a 60-day public comment period that ended in April 2013. The agencies are now focused on implementing the actions they put forth in their plans, and preparing to update their Adaptation Plans in future years.

2. Purpose of the Summary

Upon release of these documents to the public, the USGCRP Adaptation Science Interagency Workgroup (ASIWG) began a cross-cutting review of the FY13 Agency Climate Change Adaptation Plans that met the requirements outlined by CEQ in their March 2011 *Instructions for Implementing Climate Change Adaptation Planning in Accordance with Executive Order 13514*. In order to identify adaptation research and information needs, the Working Group reviewed each agency adaptation plan with special attention towards:

- (1) Most common and specific research and information needs for agency adaptation;
- (2) Current and planned activities that could meet these needs for agency adaptation; and
- (3) Opportunities for potential collaboration given similar existing or planned research and actions.

The ASIWG conducted an initial survey of the plans to identify and list all references to knowledge gaps and general research and information needs across the plans. From this list, the ASIWG identified general themes related to research and information that cut across many of the plans. The ASIWG then reviewed the plans again, looking for mentions of current and planned research and information efforts that could help address those identified themes.

This document outlines the common research and information themes and needs identified through a thorough analysis of the 27 Federal agency plans publicly available to the ASIWG in February 2013 when the development of this summary began, and the existing efforts that may align with those themes and needs. This distilled information can help Federal Agencies and public and private-sector partners to:

- Understand the current most common research and information needs for adaptation as identified by agencies;
- Connect to existing tools and resources that may help meet their needs;
- Enhance and guide conversations between existing USGCRP Interagency Working Groups
- (IWGs) about how best to meet those needs; and
- Inform future Federal research agendas related to climate change adaptation, preparedness, and resilience-building actions.

This summary report can inform work toward advancing the preparedness-related goals and actions laid out in the President's Climate Action Plan by providing example applications of several tools and resources already available for addressing common Federal agency adaptation needs. This document can also inform the development of research strategies to enable science-producing Federal agencies to continue producing climate science and climate

Box 2. Common Research and Information Needs Identified Across the FY13 Agency Climate Change Adaptation Plans

- (1) **Built Infrastructure:** Identification of best practices and standardizing procedures for infrastructure planning, building, and maintenance.
- (2) **Communication and Training:** Development of effective communication, training, and educational tools on climate change risks and adaptation.
- (3) **Human Health:** Improved capacity to quantify and reduce the impacts of climate change on the health of agency employees and/or external agency partners.
- (4) **Natural Resources:** Expanded science capacity to inform decisions on natural resources.
- (5) **Disaster Response:** Expanded capacity to anticipate and respond to natural disaster-related damages.
- (6) **Regional Climate Information and Modeling:** Improved capacity to provide regional climate information and models.
- (7) **Observations and Monitoring:** Expanded observation and monitoring capabilities.
- (8) **Decision Support Tools and Resources:** Creation of and accessibility to adaptation tools and useful resources.

⁸ All of the information in this analysis is available to the public. In addition, the information gathered in this analysis originated from the FY13 Agency Adaptation Climate Change Adaptation Plans, Appendix A of the FY13 Strategic Sustainability Performance Plans submitted by the agencies in June 2012.

change information that can be translated into forms useful for on-the-ground action to prepare, adapt, and build resilience.

3. Summary Findings

Effective adaptation planning demands many kinds of information, for many different purposes (e.g. when identifying best practices to build resilient infrastructure, the planning community demands a level of detail that is different from the engineering community). Successful climate change adaptation also requires a high level of coordination, integration, and interdisciplinary thinking, as the problems faced are multifaceted, with multiple definitions and solutions.

The research and information needs identified in the agency adaptation plans fell into a number of categories. In some cases, the need represented an actual lack of scientific information that would be useful to inform adaptation planning. In other cases, the perceived need indicated that the agency is not aware of information that already exists, or that the information that does exist is not in a format easily accessible or actionable.

Nearly every FY13 Agency Climate Change Adaptation Plan highlighted the need of agencies for robust scientific information that useful to inform climate change adaptation decisions and actions. The research and information needs identified ranged from specific types of scientific information and scientific techniques to science-translation tools, and techniques for integrating climate science into existing agency decision structures. Broadly, the need for research to inform the development of climate change adaptation communication tools, vulnerability analyses, and adaptation best-practices was frequently cited. More specifically, improved knowledge of certain specific systems, development of improved technologies, and expanded techniques to address specific modeling challenges were among the needs commonly cited.

The ASIWG identified eight common themes across the research and information needs communicated in the plans (see Box 2). Of these eight themes, needs related to ***built infrastructure*** (26 out of 27 plans), ***communication and training*** (24 out of 27 plans), and ***human health*** (22 out of 27 plans) were the most common, appearing in nearly every plan analyzed.

- The need for research and information to inform decisions on ***built infrastructure*** centered on the agencies' need for vulnerability analysis and the development of best practices for resilient buildings, dams, roadways, railways, etc. Some plans also mentioned the need to better understand climate change impacts to more abstract forms of infrastructure, such as economic markets, the electrical grid, and the balance of energy supply and demand.
- In addition, the need to develop or expand effective methods for ***communicating*** about ***and training*** associated with climate-change adaptation for both agency employees (19 out of 27 plans) and outside entities (15 out of 27 plans) was identified.
- The cross-cutting need for ***human-health***-related research and information centered on the need to better understand human-health vulnerabilities and identify effective risk-reduction practices. Heat stress and hazards associated with extreme weather events were among the most commonly cited health-related concerns, with many agencies also citing concerns about climate change impacts to respiratory health and the pattern and extent of infectious disease outbreaks.
- The need for research and information to inform decisions regarding ***natural resources*** were commonly cited but varied by agency. The Plans described the need to better understand and respond to impacts on coastal and oceanic, Arctic, agricultural, general terrestrial, species-based, and freshwater resources, for example.

- Agencies with *disaster response* functions embedded within their missions and authorities frequently cited the need to better understand and respond to changes in the pattern and intensity of extreme weather events.
- Agencies responsible for science production often cited the need for expanded *observation and monitoring* methodology, whereas agencies using science and information primarily produced by others cited the need for *regional climate information* and *decision support tools and resources*.

Finally, it is notable that agencies expressed needs related to both science production (improved monitoring capabilities and techniques, new approaches for incorporating climate change into existing climate and risk models, developing building standards and best practices) and science consumption (decision support tools, access to up-to-date best-available scientific information).

More detailed information regarding the specific needs identified within these themes is presented in the *Detailed Findings* section and Appendix A.

4. Examples of Agency Adaptation Research and Information Needs

The table below lists examples of specific research and information needs under each of the eight themes described above, along with examples of current and planned research actions that may help address those needs (see Table 1).

Table 1: High Level Research and Information Needs Identified within the Current and Planned Activities⁹

| 1. BUILT INFRASTRUCTURE: Identification of best practices and standardizing procedures for infrastructure planning, building, and maintenance. | |
|--|--|
| Research and Information Needs | <ul style="list-style-type: none"> ▪ Infrastructure Vulnerability Assessments ▪ Historic and Cultural Resources Vulnerability Assessments ▪ Economic Impact and Opportunity Assessments ▪ Infrastructure Adaptation Best Practices |
| Example Current Activity | <u>Digital Coast</u> is a web-based tool that allows users to visualize the impacts of sea level rise, including a slider bar to show how various levels of sea level rise will affect coastal communities and built infrastructure . This tool was developed through collaboration between the U.S. Army Corps of Engineers (USACE) and the Department of Commerce's (DOC) National Oceanic and Atmospheric Administration (NOAA). |
| Example Planned Activity | The DOC National Institute of Standards and Technology (NIST) is planning to build a first-of-its-kind facility in the U.S. to conduct large-scale tests of structures exposed to fire conditions. They will also develop an integrated software tool to predict the structural impacts of more extreme weather conditions. The research underpins the development of standards, technology, and best practices for cost-effective improvements to the safety and security of buildings. ¹⁰ |
| 2. COMMUNICATION AND TRAINING: Development of effective communication, training, and educational tools on climate change risks and adaptation. | |

⁹ Table 1 includes the very high-level research and information needs identified throughout the analysis. More detail on the specifics of each high-level need appears in Appendix A.

¹⁰ U.S. Department of Commerce. *Strategic Sustainability Performance Plan - Appendix 1: Climate Change Adaptation Plan. Action 7 - Key Milestones*. June 2012: p. 21. Website: <http://www.osec.doc.gov/oas/Documents/OSEEP/Annual%20Rpts%20&%20Scrcards/DOC%202012%20SSPP%20Public%20Release%20FINAL%202-4-2013.pdf>

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|---|--|
| Research and Information Needs | <ul style="list-style-type: none"> Government Employee Training External Partner Training Peer Exchange Programs and Workshops on Best Practices Online Curriculum and Training |
| Example Current Activity | The General Service Administration (GSA) conducted climate literacy training for their employees in two regions (Kansas City, MO and Washington, DC). The training focused on region-relevant climate change impacts, risks, and vulnerabilities to GSA's operations, facilities, and overall mission. |
| Example Planned Activity | The U.S. Department of Housing and Urban Development (HUD) is looking for opportunities to strengthen training, enforcement, and compliance with existing floodplain and wetland regulations. One training opportunity they have already identified is to educate grantees on eligible uses of Community Development Block Grant disaster recovery (which includes relocating residents out of floodplains). ¹¹ |
| 3. HUMAN HEALTH: Improved capacity to quantify and reduce the impacts of climate change on the health of agency employees and/or external agency partners. | |
| Research and Information Needs | <ul style="list-style-type: none"> Heat Stress Hazard-related Human Health Concerns The Role of Human Health in the Context of Multiple Stressors Understanding and Responding to Climate Change-related "Bio Threats" Climate Change and Air Quality Interactions (Indoor and Outdoor) |
| Example Current Activity | Within the U.S. Department of Health and Human Services (HHS) Center for Disease Control (CDC), the <u>Building Resilience Against Climate Effects</u> (BRACE) framework provides funding and guidance for State, territorial, and Tribal health departments to analyze and reduce the health consequences of climate change. |
| Example Planned Activity | The DOC Bureau of Economic Analysis is planning to update U.S. Gross Domestic Product accounts with expanded health care spending information. This effort will improve our understanding of where in the U.S. climate change-related health impacts are currently occurring. ¹² |
| 4. NATURAL RESOURCES: Expanded science capacity to inform decisions on natural resources. | |
| Research and Information Needs | <ul style="list-style-type: none"> Coastal and Oceanic Research and Information to Inform Adaptation Actions Arctic Research and Information to Inform Adaptation Actions Agricultural Research and Information to Inform Adaptation Actions General Terrestrial Ecosystem Research, Information, and Management to Inform Adaptation Actions Species-based Research and Information to Inform Adaptation Actions Freshwater Research and Information to Inform Adaptation Actions |
| Example Current Activity | The first " <u>National Fish, Wildlife and Plants Climate Adaptation Strategy</u> " was compiled under the co-leadership of NOAA, the Department of the Interior (DOI) U.S. Fish and Wildlife Service (FWS), and the state of New York that aims to provide a Nation-wide "blueprint for coordinated action...to safeguard the Nation's valuable natural resources in a changing climate. " |
| Example Planned Activity | A collaboration between the US Army Corps of Engineers (USACE), DOI Bureau of Reclamation, and the University Corporation of Atmospheric Research's (UCAR) Cooperative Program for Operational Meteorology, Education and Training (COMET) group is working to produce training material that will help professionals faced with questions about climate change and water resources. ¹³ |

¹¹ U.S. Department of Housing and Urban Development. *Climate Change Adaptation Plan*. Proposed Future Actions to Enhance HUD's Current Climate Change Efforts - Actions to Better Understand Climate Change Risks and Opportunities. June 2012: p. 34. Website: http://portal.hud.gov/hudportal/documents/huddoc?id=SSP2012_Apx_CCAadaptPlan.pdf

¹² U.S. Department of Commerce. *Strategic Sustainability Performance Plan - Appendix 1: Climate Change Adaptation Plan*. Action 5 - Key Milestones. June 2012: p. 21. Website: <http://www.osec.doc.gov/oas/Documents/OSEEP/Annual%20Rpts%20&%20Scrcards/DOC%202012%20SSPP%20Public%20Release%20FINAL%202-4-2013.pdf>

¹³ U.S. Army Corps of Engineers. *2012 Sustainability Plan - Public Version*. Section 3.3.3. Training to Support Adaptation. November 2012: p. 21. Website: http://www.usace.army.mil/Portals/2/docs/Sustainability/Performance_Plans/USACE_Sustainability_Plan_2012_Public_w_Appendices_20121116.pdf

5. DISASTER RESPONSE: Expanded capacity to anticipate and respond to natural disaster-related damages.

| | |
|---------------------------------------|--|
| Research and Information Needs | <ul style="list-style-type: none"> ▪ Modeling of Future Hazards and Natural Disasters ▪ Assessment of Specific Actions to Improve Emergency Preparedness |
| Example Current Activity | The Department of Homeland Security (DHS) Federal Emergency Management Agency (FEMA) <u>HAZUS</u> is a standardized methodology for estimating potential losses from natural disasters like earthquakes, floods, and hurricanes. The software is increasingly being used for risk assessment purposes, but can also be used to support rapid impact assessment after a disaster strikes, and to support planning and preparedness measures. |
| Example Planned Activity | The <u>Citizens Advisory Recovery Team (CART)</u> , a group of city officials, business leaders, community leaders, and citizens, formed in Joplin, MO in response to the catastrophic tornado that hit their town in May 2011. With support from FEMA's Long-Term Recovery Task Force, HUD, EPA, and the American Institute of Architects, CART conducted public input and community sessions to identify recovery needs. The Department of Education (DOEd) is planning to use this input to examine the role of schools in addressing emergency management. ¹⁴ |

6. REGIONAL CLIMATE INFORMATION AND MODELING: Improved capacity to provide regional climate information and models.

| | |
|---------------------------------------|---|
| Research and Information Needs | <ul style="list-style-type: none"> ▪ Improved Regional Modeling Capabilities and Access to Regional Climate Data |
| Example Current Activity | Federal and non-Federal programs are building capabilities and providing capacity to support decision makers with actionable information for climate adaptation. NOAA's <u>Regional Integrated Sciences and Assessment (RISA)</u> teams build capabilities to understand how actionable information for climate adaptation can be developed, while the NOAA <u>Regional Climate Services Directors (RCSD)</u> and <u>Regional Climate Centers (RCC)</u> provide ongoing support for decision makers, particularly in the coastal and marine sectors. DOI's <u>Climate Science Centers (CSC)</u> provide capacity to produce actionable climate information both for ecosystem managers participating in the network of <u>Landscape Conservation Cooperatives (LCC)</u> and for other DOI bureaus. The USDA's <u>Cooperative Extension System</u> and the <u>Forest Service's Research Stations</u> are drawing on the RISAs, RCSDs, CSCs and LCCs to better serve land manager's needs for climate information. In addition, USDA is building on the existing network of Federal climate science research and action centers with the creation of seven new <u>Regional Climate Hubs</u> to deliver tailored, science-based knowledge to farmers, ranchers, and forest landowners. These hubs will work with universities and other partners, including DOI and NOAA, to support climate resilience. |
| Example Planned Activity | The Third National Climate Assessment includes eight region-specific chapters that provide regional climate change information. The USGCRP is working with partners to host multiple Regional Climate Scenario <u>webinars</u> and develop summaries of the 80-page technical <u>scenarios</u> released and produced by NOAA with collaboration from many partners for each of the eight NCA regions. ^{15,16} In addition, the USGCRP worked with NOAA and the Regional Climate Scenario authors to distill the 80-page technical documents into 2-page summaries with information that outlines the observed regional climate trends and future regional climate scenarios. |

7. OBSERVATIONS AND MONITORING: Expanded observation and monitoring capabilities.

| | |
|---------------------------------------|--|
| Research and Information Needs | <ul style="list-style-type: none"> ▪ Improved Monitoring Capability ▪ Improved Use of Monitoring and Records to Inform Adaptation Priorities ▪ Expand Species-specific Monitoring Capabilities ▪ Expand Monitoring of Human and Social Systems |
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¹⁴U.S. Department of Education. *FY 2012 Climate Change Adaptation Plan*. June 2012: p. 3. Website: <http://www2.ed.gov/about/reports/strat/sustainability/2012-climate-change-plan.pdf>

¹⁵ National Climate Assessment and Development Advisory Committee. *Draft Third National Climate Assessment*. January 2013. Website: <http://ncadac.globalchange.gov>

¹⁶ National Climate Assessment and Development Advisory Committee. *Scenarios for Climate Assessment and Adaptation*. January 2013. Website: <http://scenarios.globalchange.gov/scenarios/climate>

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| Example Current Activity | In 2004, NOAA established the <u>North Pacific Climate Regimes and Ecosystem Productivity Program</u> (NPCREP) to improve their understanding of how climate fluctuations impact the North Pacific and Bering Sea ecosystems. The project maintains an on-going observing system in order to monitor changes and add to the long-term record of data in the region. |
| Example Planned Activity | NOAA will deploy 6 biophysical moorings in the Arctic and complete their “northern extension” of the Bering Sea bottom trawl survey for groundfish and invertebrate resources. This expanded monitoring and research will help NOAA and the U.S. Coast Guard better predict and respond to changes in the distribution of fish and protected species in the Arctic . |
| 8. DECISION SUPPORT TOOLS AND RESOURCES: Creation of and accessibility to adaptation tools and useful resources. | |
| Research and Information Needs | <ul style="list-style-type: none"> Adaptation Decision Support Tools and Resources |
| Example Current Activity | The USGCRP’s Interagency Climate Change and Human Health Group (CCHHG) developed the <u>Metadata Access Tool for Climate and Health</u> (MATCH) which serves as a publicly available online clearinghouse of Federal metadata that pertains to climate and health. |
| Example Planned Activity | The USGCRP is in the early stages of developing a <u>Global Change Information System</u> (GCIS) that will provide a web-based source of authoritative, accessible, usable, and timely information about climate and global change with a specific resource page and clearinghouse function planned for adaptation. |

Detailed Findings

Multiple research and information needs were identified in the FY13 Agency Climate Change Adaptation Plans to support the ability of Federal agencies to address and manage the impacts of climate change impacts on their missions, operations, and facilities. The section below provides detailed information about these specific needs, by theme.

1. Built Infrastructure

OVERVIEW

Climate change and its associated impacts, including thawing permafrost, sea-level changes, elevated temperatures, shifts in species distribution (including the distribution of pests and pathogens), as well as increases in the frequency and severity of natural disasters (such as floods, hurricanes, and forest fires) will present new challenges for built infrastructure. In some cases, a better understanding of the timing, location, and extent of change is needed in order to identify, plan for, and implement necessary infrastructural changes.¹⁷ In other cases, efforts to improve infrastructure resilience are mainly hindered by the availability of cost-effective and broadly accepted best practices.

All but one of the 27 plans mentioned infrastructure-related concerns as a result of climate change impacts. Infrastructure resilience was an overarching theme that came up in multiple plans, regardless of the type and mission of the agency. Many agencies cited the need for more research and information to inform infrastructure vulnerability assessments. Agency adaptation plans also identified the need for standardizing procedures and best practices in the planning, construction, management, maintenance, and repair of built infrastructure to enhance overall stability in the face of a changing climate. Other areas of interest for some agencies included techniques for sustainable building and the protection and preservation of natural and cultural resources. While many agencies considered traditional built

¹⁷ U.S. Department of Transportation. *Climate Adaptation Plan: Ensuring Transportation Infrastructure and System Resilience*. June 2012: p. 6. Website: <http://www.dot.gov/mission/sustainability/2012-dot-climate-adaptation-plan>

infrastructure (such as buildings, dams, roadways, and railways), some agencies were concerned with more-diffuse built infrastructure such as the electrical grid (DOE, DHS, TVA, Department of Treasury) and food-production systems (USDA, DOT). Still other agencies discussed abstract forms of social infrastructure, such as economic markets (DOC, OPIC, USDA Foreign Agricultural Service). In addition, when considering sustainable building practices, green infrastructure was considered part of the built environment by some agencies.

RESEARCH AND INFORMATION NEEDS

Infrastructure Vulnerability Assessments

The need for research and information to inform built infrastructure vulnerability assessments at relevant scales was included by many agencies. Several categories of information needs central to supporting infrastructure vulnerability assessments were included. Improved information about the timing, location, and extent of environmental change was a major theme of need. More specifically, many agencies expressed needs for improved predictive capabilities at relevant scales. For example, more information about the pattern and extent of permafrost thaw could help inform infrastructure adaptation measures in the Arctic. In addition, while some regions have more developed models of sea level rise and flood risk, other regions are in need of this type of information. Some agencies also described a need to improve their understanding of multi-stressor impacts. For example, DoD is working to understand how water shortages, invasive species, and land use change combine and interact to affect DoDs missions in the Southwest. Another example cited in several plans was the potential for climate change to affect both energy supply and energy demand. Extreme weather events and drought in regions relying on hydroelectric power may compromise electrical supply. At the same time, rising summer temperatures will likely result in increased seasonal energy demands. The need to better understand how climate change will impact the supply of and demand for energy was reiterated by a number of agencies. EPA was specifically interested in better understanding how climate change will affect energy efficiency programs. While not necessarily a direct research need, several agencies also cited the need to identify critical facilities and infrastructure to appropriately prioritize adaptation actions.

Historic and Cultural Resources Vulnerability Assessments

The need to assess vulnerabilities to historic and cultural resources was expressed by several agencies. Both the National Archives and Records Administration (NARA) and DOI cited the need to preserve and protect historic property as the climate changes. DOI stressed a need to “incorporate traditional knowledge in assessing climate change effects on cultural, natural, and heritage resources and developing appropriate adaptation strategies” (DOI, p. 7). Additionally, DOI stated a need to update and/or implement cultural resource monitoring systems to track environmental changes that may affect cultural resources (*see Section 7 below on Observations and Monitoring*). The need to better understand the impacts of climate change on natural resources pertinent to native and indigenous communities is also discussed below (*see Section 4 below on Natural Resources*).

Economic Impact and Opportunity Assessments

Several agencies noted the need to improve their understanding of the linkages between built infrastructure and economic considerations. Extreme weather events, drought or flooding in agricultural regions, and an increased interest in climate-friendly and green technologies, for instance, all have the potential to measurably effect the economy. The Overseas Private Investment Corporation (OPIC) notes that the financial viability of agriculture, forestry, fisheries, coastal, and other water-dependent projects (such as wastewater treatment) may be challenged due to climate change (OPIC, p. 7). OPIC is interested in identifying projects in emerging markets that promote global renewable energy and OPIC may also help investors identify sources of grant funding for adaptation. DOC is planning a number of economic adaptation actions including the factoring of resilience into economic development investments (*see the Mainstreaming Adaptation into Infrastructure Planning & Grant Programs sub-section below*), helping

Box 3. Visualization Tool for of Potential Sea Level Rise Impacts to Coastal Communities

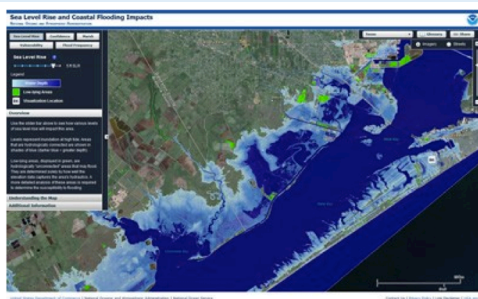
Background: Sea level rise will provide adaptation challenges for both natural resources and built infrastructure. As a result, a sea level rise web-based tool was created by the Digital Coast Partnership that allows coastal communities to visualize the potential impacts of sea level rise in their region of the country. In addition, the Digital Coast website includes a number of other helpful resources that relate to coastal adaptation. The sea level rise web-based tool was created by the Digital Coast Partnership (members from NOAA, The Nature Conservancy, the Association of State Floodplain Managers, the American Planning Association, the National Association of Counties, and the National States Geographic Information Council) with support from a number of contributors including USACE, USGS, FEMA, USDA, the National Geospatial Agency, and a number of State and Academic partners.

Adaptation Research and Information Need Addressed: The Digital Coast sea level rise viewer meets a number of the needs identified in the agency adaptation plans. The tool provides science to inform decisions regarding both *built infrastructure and natural resources*. Digital Coast also serves as a powerful *communication tool* by providing a powerful visual display of projected potential sea level rise. The *web-based tool is easily accessible* and translates up-to-date science into a friendly format for planners and decision-makers. *Region-specific* sea-level rise is incorporated into the model and users can zoom in on the region of interest to them. Finally, a cost benefit analysis of the Digital Coast was conducted by NOAA's Coastal Services Center, meeting a need for *performance metrics* to assess the effectiveness of adaptation efforts.

Strategy: The Digital Coast sea level rise viewer uses nationally consistent datasets to provide a screening level tool for management decisions. Users can view the relative confidence of the projections from scenarios, as well as the potential flood frequency, new marsh habitat, and socioeconomic vulnerability of certain areas. The website also includes resources that describe how to apply the information gained from the web-tool as well as some case studies from the field. One weakness of this tool is that it does not currently cover all coastal locations of the U.S.

Implications for Adaptation: The Digital Coast sea level rise viewer uses a scenario-based approach to allow the user to visualize the impacts of various degrees of sea level rise (up to 6ft sea level rise). This tool can help stakeholders visualize multiple potential futures and help inform future infrastructure planning processes.

Image 1: Sea Level Rise and Coastal Flooding Impacts



Resource: Digital Coast - <http://www.csc.noaa.gov/digitalcoast/>

businesses capitalize on an increased demand for green technologies, and improving the timeliness of patent application processing for climate change adaptation technologies.

USDA is interested in using green lands to enhance green employment opportunities, and DOL is interested in promoting green careers. In particular, since more than 99 percent of DOL's buildings are on 125 Job Corps Center campuses across the Nation, their Climate Adaptation Plan focuses substantially on Job Corps goals, strategy, and approach to climate change adaptation. As an education and training program, Job Corps continues to train young Americans interested in careers in emergency management, in keeping with Job Corps' mission to attract young adults, teach them relevant skills needed to become employable and independent, and help prepare them for success in life by securing meaningful jobs or opportunities for further education.¹⁸

Infrastructure Adaptation Best Practices

In their plan, DOC noted: "at present, the necessary metrics, tools, and standards needed to ensure structural and community resilience [to climate change] do not exist" (DOC, p. 12). In particular, there is a need for cost effective and performance-based design tools that support infrastructure resilience to disaster. In addition, adaptation-relevant sustainable building practices are becoming more common, but their formal incorporation into standards has not yet been achieved, although doing so is not a Federal agency mission. Examples include the strategic planting of shade trees and the use of white roofing to reduce urban heat island effects. Much more broadly, agencies need guidance on how their vulnerability analyses should actually influence planning and decision-making about built infrastructure.

CURRENT ACTIVITIES

Infrastructure Vulnerability Assessments

Several agencies have already developed tools for assessing infrastructure vulnerability. The DOT developed a grant program, "Framework on Conducting Assessments of Transportation Infrastructure Vulnerable to Climate Change Effects," which has supported the completion of five pilot studies thus far to assess infrastructural vulnerabilities to climate change and test adaptation strategies. The DOT is currently funding seven additional pilots for FY13 - FY14. With the collaboration of an international team that included NOAA, USGS, FEMA, and other U.S. Federal agencies, USACE recently updated its guidance,

¹⁸ Department of Labor. 2012 Sustainability Plan - Appendix A: 2012 Climate Change Adaptation Plan. June 2012: p. 1. Website: <http://www.dol.gov/open/sustainability/2012SustainabilityPlanAppA.htm>

published as Engineer Circular 1165-2-212 “Incorporating Sea-Level Change Considerations in Civil Works Programs” (USACE 2012). This document includes three scenarios for sea level rise as well as illustrative examples on how to incorporate these projections into the full life cycle (managing, planning, engineering, designing, constructing, operating, and maintaining) of all USACE civil works projects. Another resource for sea level rise adaptation is NOAA’s Digital Coast’s web-based tool “Sea Level Rise and Coastal Flooding Viewer” (see Box 3). Digital Coast has already been used by other entities, including the State of Florida in support of adaptation planning. Some of the agency adaptation plans provide examples of vulnerability assessments and relevant resources for other agencies to consult. For example, HUD’s plan presents assessments of flood risk, sea level rise risk, coastal storm risk, and heat risk.

PLANNED ACTIVITIES

Infrastructure Vulnerability Assessments

Many agencies are currently developing infrastructure vulnerability assessments and tools, some of which will be very applicable across other agencies. For example, the National Capital Planning Commission (NCPC) is working with Federal (NPS, FEMA, GSA, DOJ, DOI, DoD, EPA, GAO, and the State Department) and non-Federal (WMATA, PEPCO, the Smithsonian, and DC Water) partners to analyze the risks and potential impacts of climate change on infrastructure within the “Monumental Core” region in Washington, DC.¹⁹ In addition, the GSA is developing a process to identify and communicate facility risks associated with climate change. Their effort is based on NASA’s seven-step process for conducting resilience and adaptation to climate risks workshops. Building on the relationship between GSA and DOC within the Federal Adaptation Sites and Facilities Community of Practice, these agencies collaborated to develop criteria for assessing the degree of mission criticality of specific facilities to each agency (see Box 4). DOC then assessed risk to their NOAA-owned mission critical sites. From this exercise, GSA has “identified the need to imbed climate factors into our business processes” (GSA, p. 7). While more information is needed to inform built infrastructure vulnerability assessments, substantial relevant information is available now. For instance, HUD was able to utilize a number of existing GIS datasets to make spatial assessments of its infrastructure vulnerability.

DoD is concerned with how impacts to natural infrastructure may affect their mission, operations, and facilities (e.g. ability to train in excessive heat, drought, or flooding). In response to concerns about the potential infrastructural ramifications of thawing permafrost, DoD initiated a suite of projects in FY11 that aim to improve understanding and predictive capabilities related to permafrost dynamics. DoD is also funding research in the Southwest desert region and, in FY13, the Pacific to better understand region-specific threats to their built infrastructure. Research in the Southwest assesses changes to fire regimes, intermittent and ephemeral stream systems, and the interaction between land-use activity, altered water sources, and the introduction of invasive species. In the Pacific, changes in sea level, precipitation, and storm patterns will be studied to better understand how DoD missions might be affected.

Best Practices in Infrastructure Planning, Design, and Operations

Some agencies are investing in research to better understand and describe “best practices” related to infrastructure planning, design, and operation. These efforts are critical and will support the cost-effective implementation of infrastructure adaptation in other agencies. The National Research Council’s (NRC) Transportation Research Board has funded a research initiative by the National Cooperative Highway Research Program (NCHRP) 20-83(05) “Climate Change and Highway Infrastructure: Impacts and Adaptation Approaches.” The project aims to create a guidebook for planners, National Environmental Policy Act (NEPA) practitioners, designers, asset managers, and operators that will describe how adaptation can be incorporated into different stages of transportation decision making (planning, construction, and operations). Additionally, NIST is conducting research on cost-effective improvements to the safety and security of buildings during natural disasters. This research will include a “first-of-its-kind” facility for

¹⁹ National Capital Planning Commission. *Monumental Core Framework Plan*. July 2013: p. 1. Website: [http://www.ncpc.gov/ncpc/Main\(T2\)/Planning\(Tr2\)/FrameworkPlan.html](http://www.ncpc.gov/ncpc/Main(T2)/Planning(Tr2)/FrameworkPlan.html)

“experimental validation of performance-based design tools” as well as a software tool for investigating the impacts of extreme wind conditions on buildings (DOC, p. 22). In addition, the Federal Facilities Council on Hazards is currently working with groups, which establish standards. Several governmental and non-governmental groups are beginning to address the need for infrastructure best practices. Engineers Canada, the NSF Infrastructure and Climate Network, the Gulf of Maine Council on the Marine Environment, and the American Society of Civil Engineers (ASCE) Sustainability Initiative all have relevant programs working towards this goal. Multiple agencies identified the need for research to support their interactions with standards-setting bodies working on adaptation-related questions.

USDA’s Forest Service (USFS) is currently performing a “Life Cycle Inventory” database for wood products to meet Green Building standards (FY12 - FY14) (USDA USFS, p. 64). They are also working to establish a National Strategic Tree Planting Initiative that will support tree planting projects in urban and community forests (FY12 - FY15). The primary purpose of these projects is carbon sequestration, but NARA points out that strategic urban tree planting can also reduce the heat island effect and lower energy demands via natural cooling/shading (this is a good example of the co-benefits of a mitigation and adaptation measure). Finally, HUD’s Office of Healthcare Programs is planning to address the need for adaptation-related sustainable building best practices by changing construction standards in support of elderly populations particularly vulnerable to heat stress. Some of the standards they mentioned included white roofing and therapeutic roof gardens to support heat island reduction initiatives (HUD, p. 35). As above, here multiple agencies identified needs for science research and products to support their work to integrate adaptation and mitigation efforts like these.

Mainstreaming Adaptation into Infrastructure Planning and Grant Programs

Efforts to mainstream infrastructure adaptation were apparent in a number of agency plans. Some agencies are mainstreaming infrastructure adaptation into their grant programs. For instance, the HUD Community Development Block Grant currently encourages and educates grantees on building strategies to respond to impacts of current disasters and lessen the impacts of future disasters. Similarly, the DOT Federal Highway Administration (FHWA) Office of Infrastructure and Office of Planning, Environment, and Realty is planning to issue a document clarifying that adaptation activities are eligible uses of Federal-aid funds. Additionally, the DOC Economic Development Administration is mainstreaming

concerns about resilient infrastructure into their grant-based investments with plans to ensure that “economic

Box 4. Assembling Partners to Identify Resilience and Adaptation to Climate Risks to NASA Facilities

Background: In July 2009, NASA climate scientists and institutional stewards gathered at the Kennedy Space Center to explore NASA’s adaptation needs. Center-specific climate risk workshops began in May 2010 and have reached over 40% of NASA staff thus far. A total of 8 internal grants have helped to support these workshops via the development and/or advancement of adaptation strategies, climate science and impacts assessments, student research, and the application of Earth science to decision making. An additional 13 awards have been issued for the 2011-2013 time period.

Adaptation Research and Information Need Addressed: NASA’s Climate Risk Workshops directly address the need for *built infrastructure vulnerability assessments, communication, and the need for regional climate information.*

Strategy: NASA’s Office of Strategic Infrastructure (OSI) is partnering with the Earth Science Division to design and carry out NASA Center-specific workshops that are relevant to local and regional risks associated with climate change. The workshops were based on methodologies that were developed for (and well received by) New York City planners as part of the New York City Panel on Climate Change. Climate information handouts were developed for each workshop that included site-specific climate trend data and projections for relevant climate variables based on multiple futures.

Implications for Adaptation: The handouts provided at NASA’s Climate Risks Workshops have received an award of Excellence in the International Summit Awards of the Society of Technical Communications. NASA’s workshops can be used as a model for other agencies looking to develop similar training and communication material. NASA’s seven step process includes:

1. Conduct inventory of systems & assets
2. Identify current and future climate hazards
3. Characterize risk of climate on systems and assets
4. Develop initial adaptation strategies
5. Identify implementation approaches & funding
6. Identify opportunities for coordination
7. Integrate into management and planning

Image 2: NASA’s Climate Risk Workshop to Protect People, Natural, and Built Systems at NASA Facilities

| Protecting people, natural, and built systems at NASA sites: NASA’s Climate Risk Workshop Progress | | | | |
|---|----------|------------------------|---------------------|---------------|
| Installation | Workshop | Share of NASA’s assets | | |
| | | Onsite Staff | Land Managed | Const. Assets |
| Agency-wide | 7/2009 | 58,000 | 330 mi ² | \$32 B |
| Kennedy Space Center, FL | 5/2010 | 12.1% | 66.4% | 18.5% |
| Ames Research Center, CA | 2/2011 | 7.8% | 1.0% | 15.1% |
| Dryden Flight Research Center, CA | 8/2011 | 2.4% | 0.4% | 1.2% |
| Langley Research Center, VA | 9/2011 | 6.4% | 0.4% | 11.3% |
| Johnson Space Center, TX | 3/2012 | 12.7% | 0.8% | 7.0% |
| Progress as of June 2012 | | 41.4% | 69.0% | 54.1% |
| Stennis Space Center, MS | 10/2012 | 7.1% | 9.9% | 9.4% |
| Wallops Flight Facility, VA | 11/2012 | 1.7% | 2.9% | 2.8% |
| Planned by June 2013 | | 50.2% | 81.8% | 66.3% |

Resource: NASA October 2012 Resilience and Adaptation to Climate Risks Workshop - <http://www.nasa.gov/centers/stennis/home/resandadaptworkshop.html>

development plans and public infrastructure projects...[are] developed with future climate change projections in mind” (DOC, p. 17). Other agencies are mainstreaming infrastructure adaptation into their legislative criteria. “At the DoD level, Unified Facilities Criteria (UFC) 2-100-01, paragraph 3-5.6.2.3 requires master planners to consider climatic changes (including but not limited to: changes in land use and population density in the vicinity of installations; changes in climatic conditions such as temperature, rainfall patterns, storm frequency and intensity and water levels) when crafting long-range installation infrastructure master plans” (DoD, p. 9).

OPPORTUNITIES FOR COLLABORATION

There are some clear opportunities where collaboration may be beneficial for building infrastructure resilience. For example, DOI, NARA, and the Advisory Council on Historic Preservation [ACHP] expressed concern regarding the preservation of historic property. Additionally, NARA, NCPC and several other agencies identified the potential for sustainable building technologies to support climate change adaptation efforts. The use of shade trees, green roofs, and high-albedo pavement, for example, all contribute to the reduction of heat-island effects (another example of the co-benefits of mitigation and adaptation measures). NARA is looking to the Leadership in Energy and Environmental Design (LEED) certification process to guide its infrastructural adaptation efforts (NARA, p. 14). Another area of potential collaboration surrounds transportation-related infrastructure concerns. The U.S. Postal Service (USPS) mentioned the desire to communicate with DOT and other relevant stakeholders regarding future adaptation planning.

2. Communication and Training

OVERVIEW

Climate change adaptation is not a simple challenge to define, address, or communicate. In order to better facilitate the adoption and implementation of adaptation strategies, agencies are pursuing a variety of methods for training and information exchange related to this topic.

The vast majority of agency adaptation plans identified the need to develop, expand, or support communication tools and training for agency employees (19 out of 27 analyzed) and outside entities such as private sector or NGO partners (15 out of 27 analyzed). In addition, some agencies intend to build or have already built support for climate change adaptation into their grant programs and will provide relevant educational material to grant applicants (HUD, OPIC, DHS).

RESEARCH AND INFORMATION NEEDS

Climate Change Communication and Training

Types of training proposed in the agency plans were widely varied. One common theme was the development of training materials and tools that would inform communities, planners, and grantees about how to incorporate climate change adaptation into their infrastructure plans (DHS, DOC, DOT, HUD). Another theme was the integration of climate change and disaster risk reduction considerations into employee safety training materials (DoD, USPS). Many agencies are also planning to improve upon disaster preparedness training (DHS, DOEd, SBA) and to train staff to identify natural hazard risks and opportunities (DOS). A number of agencies also proposed actions to develop material that would train people about the impacts of and responses to climate change (DOL, DOEd, EPA, NASA, USDA). Another theme was the need for climate change science training (DOI, USACE, DOC, EPA, USDA) and training in the use of decision support tools (EPA). Finally, the development of training approaches that focus on awareness building was mentioned by a number of agencies (EPA, USDA, GSA, HHS, TVA, USPS). The need for appropriate framing of adaptation training materials will be critical in reaching a broad variety of audiences. For instance, USDA noted that adaptation training for farmers must take into account public perceptions of climate change.

Box 5. Building Climate Literacy for Internal Staff and External Partners through Training

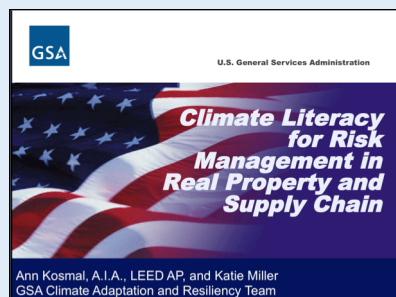
Background: GSA has launched a program to raise awareness of climate change challenges that Federal Government agencies will face. GSA has already provided climate literacy training briefings internally for their Federal Acquisition Service (FAS), Public Building Service (PBS), and Regions 1 and 7 (Northeast and Southwest) as well as for several of their customers, for example, DoD, DHS, and the American Institute of Architects.

Adaptation Research and Information Need Addressed: GSA's Climate Literacy Training addresses the need for *communication* regarding climate change adaptation. It also addresses the need for information to inform decisions about *built infrastructure*.

Strategy: In 2012, GSA worked with NOAA to develop a process for assessing climate change risks to agency's facilities and then piloted a process to explain these risks to customer agencies. GSA also conducted pilot scenario-based planning exercises in two GSA regions (in Kansas City, MO and Washington, DC) to develop capacity for anticipatory planning and to provide USGCRP with identified science needs and formats.

Implications for Adaptation: GSA plans to provide technical support based on customer needs. In addition, GSA will continue to work with NOAA to identify sites leased from GSA that are particularly at risk. GSA's efforts to improve climate literacy and infrastructure adaptation planning could be useful and/or directly transferrable to other agencies. They will also be directly communicating with other agencies via a Request for Information (RFI) to better identify climate adaptation needs and climate science services.

Image 3: GSA's Internal Climate Literacy for Risk Management in Real Property and Supply Chain Training



Resource: GSA

CURRENT AND PLANNED ACTIVITIES

Government Employee Training

Many agencies are planning to develop employee training programs, including the SBA, HUD, HHS, DOS, EPA, USPS, DHS, DOC, NARA, and the Commodity Futures Trading Commission (CFTC). A number of agencies have already developed effective communication tools for their employees that could benefit other agencies. For example, several agencies have developed employee training curriculum in the form of site specific climate risk workshops (NASA, see Box 4), briefing sessions (DOT), online curriculum (USDA), and climate literacy training (GSA). The curriculum developed by NASA and GSA may be particularly easy for other agencies to utilize and customize for their own agency (see Boxes 4 and 5). Due to the region-specific nature of NASA and GSA's training programs, agencies with little to no adaptation training resources may be able to make use of existing trainings that other agencies have given and tailor them to the needs of their agency. In other cases, plans to develop employee training are quite specific to the agency's mission and may benefit more from other intra-agency training program material. For instance, EPA is planning to develop guidance and training for rule writers to help them understand the implications of climate change impacts. In order to do this, they plan to structure the guidance to reflect another rulemaking guidance document they developed on addressing children's health and environmental justice.²⁰ Another good resource for employee-based training is the instructional package developed by USDA to provide guidance on climate change training for all Forest Service employees. The package includes resources for three different types of training: (1) self-paced online training; (2) online training and group discussion; and (3) all day training.

External Partner Training

Several agencies are planning to develop or enhance training for outside entities (the public, private businesses, NGOs, grantees, or other government agencies). Occasionally, training originally developed for internal agency employees end up informing training development for outside entities. NASA's workshop process (see Box 4) has already been used by external entities such as GSA and the City of New York. A number of agencies, including HUD, DHS, DOE, DOL, DOC, USDA, HHS, DOS, USACE, USDA, DOI, DOT, and SBA, have already been involved in developing climate change adaptation communication tools for outside

entities. These tools range from websites, to peer exchange workshops, to hands-on educational workshops.

Peer Exchange Programs and Workshops on Best Practices

Peer exchange programs and workshops, in particular, foster the collaborative environment that is so critical to working on climate change-related issues. DOT's FHWA peer exchange workshops have been successful in providing a

²⁰ U.S. Environmental Protection Agency. *Strategic Sustainability Performance Plan for FY2010 - FY 2020*. June 2012: p. 35. Website: http://www.epa.gov/oainttrnt/documents/sspp2012full_508.pdf

forum for State representatives to discuss effective approaches to climate change adaptation. Another example of peer exchange is USDA's NIFA support to the Extension Disaster Education Network (EDEN) which links Extension educators across the country, enabling resource sharing to reduce the impact of disasters. Resources currently available on the website range from online courses (on a variety of topics including Plant Biosecurity Management, Pandemic Preparedness for Business, and Animal Agrosecurity and Emergency Management), to information on focused topics (e.g. swine influenza, West Nile virus, Hurricanes Sandy and Isaac, drought, floods, etc.), to whitepapers produced by EDEN. In addition, an eXtension Community of Practice on disaster issues has been formed to provide a platform for collaborative work and public outreach.

Online Curriculum and Training

Similarly, the USDA hopes to establish regional farming networks to encourage the exchange of region-relevant information. The "Why do we care about climate change" online curriculum developed by USDA provides a more general resource for both employees and stakeholders on the impacts of climate change on agriculture and natural resources. Both DHS and HUD identified the need to develop training that could be relevant to both employees and stakeholders—so the USDA's online curriculum could be a useful model for these agencies. Finally, NOAA plans to offer climate adaptation and resilience webinars and training programs geared towards coastal community planners including:

- Mapping and Visualizing Sea Level Rise;
- Marshes on the Move: A Manager's Guide to Understanding and Using Model Results Depicting Potential Sea Level Rise Impacts on Coastal Wetlands;
- Coastal County Snapshots;
- Roadmap for Adapting to Coastal Risk;
- Climate Adaptation for Coastal Communities;
- Planning for Climate Change;
- Coastal Inundation Mapping; and
- Introducing Green Infrastructure for Coastal Resilience.²¹

Identifying the communities most in need of training is also an important part of the climate change adaptation outreach process. DOC is working with their partners to better identify these groups and also notes the importance of providing technical assistance alongside trainings or other educational products.

USACE is collaborating with the DOI Bureau of Reclamation and the UCAR Cooperative Program for Operational Meteorology, Education and Training (COMET) group to produce training material that will help professionals faced with questions about climate change and water resources. Many of the training topics address the challenges associated with creating regionally relevant hydrologic models that appropriately incorporate climate projection information (USACE, p. 25 for a description of topics covered). Training modules are currently being tested and will be made available through UCAR's remote training facilities. The Climate Change and Water Working Group (CCAWWG), an informal consortium of Federal agencies (Reclamation, USACE, USGS, NOAA, NASA, FEMA, and others) having missions related to water resources and climate impacts, is also contributing to trainings relevant to linking hydrologic and climate models (*see Natural Resources in Section 4*).

²¹ U.S Department of Commerce. *Climate Change Adaptation Strategy and FY 2013 Action Plan*. Action 10. Implementation Method. June 2012: p. 24. Website: <http://www.osec.doc.gov/oas/Documents/OSEEP/Annual%20Rpts%20&%20Scrcards/DOC%202012%20SSPP%20Public%20Release%20FINAL%202-4-2013.pdf>

OPPORTUNITIES FOR COLLABORATION

Interagency collaboration has spurred the development of some useful communication tools. Many of these collaborations are built on the synthesis of scientific/expert information for a non-expert audience. As noted above, USACE is collaborating with the DOI Bureau of Reclamation and COMET to produce training material that will help professionals faced with questions about climate change and water resources. This is a complex topic that requires interdisciplinary collaboration. A number of the future communication-related adaptation actions mentioned the need for interagency collaboration. For example, NOAA and FEMA are planning to partner in delivering Tsunami Awareness and Coastal Community Resilience training to relevant communities. DOE has also identified the need to collaborate with the DOI Fish and Wildlife Service as well as the National Ocean Council (NOC) to develop climate change-related K-12 curriculum. Finally, as efforts to develop adaptation-relevant training material continue, easy access to pre-existing programs/tools will allow agencies to effectively leverage existing resources and not recreate the wheel. To this end, the Interagency Land Management Adaptation Group (ILMAG), an informal consortium of Federal agencies having land-management missions and climate change questions, is currently working on a training database. Their goal is to create a self-maintained system where users can populate a web-based database that describes training resources. This effort includes the development of an online calendar so groups can share webinars and other training sessions.

3. Human Health

OVERVIEW

Climate change can have a number of direct and indirect effects on human health. For example, rising temperatures can contribute to the number of deaths and illnesses due to heat stress,²² and extreme weather events can cause injuries and mental stress.²³ Increases in heat-related and drought-related wildfires together with heat-related increases in tropospheric ozone can have negative effects on respiratory health. There is also growing concern regarding the influence of climate change on rates and ranges of infectious diseases.²⁴

A total of 22 out of 27 agencies identified the need to quantify and reduce human health risks from climate change, making research and information needs for human health another major common theme in most plans. Overall, there is a need to identify, to a greater level of detail, where (both within and outside of the U.S.) climate change related health impacts are currently occurring or will likely occur. Many agencies focused on concerns regarding employee health and frequently cited the need to consider how rising temperatures and potential increases in on-the-job hazards would impact employees. The need to understand and respond to changes in indoor and outdoor air quality was a less frequently cited concern, although several agencies did stress this need. Other needs included national health security, natural disaster-related health concerns, environmental justice, and a better understanding of how climate change will affect the spread of disease.

RESEARCH AND INFORMATION NEEDS

Heat Stress

Excessive heat can result in deadly illnesses like heat exhaustion and heat stroke and can also exacerbate pre-existing medical conditions. Heat is currently the leading cause of weather-related death in the U.S.²⁵ and was also the most

²² Department of Homeland Security. *Climate Adaptation Road Map*. June 2012: p. 14.

Website: <http://www.dhs.gov/publication/sustainability-performance-plan>

²³ Berry, H.L., K. Bowen, and T. Kjellstrom. *Climate change and mental health: a causal pathways framework*. International Journal of Public Health. 2010: 55, 123-132.

²⁴ U.S. Department of Health and Human Services. *HHS Climate Adaptation Plan*. June 2012: p. 6.

Website: <http://www.hhs.gov/about/sustainability/adaptation-plan.pdf>

²⁵ Environmental Protection Agency. *Climate Change Indicators in the United States*. 2012: p 72. Website: <http://www.epa.gov/climatechange/science/indicators/>

frequently cited health concern in the agency adaptation plans. While many plans mentioned concerns pertaining to heat stress, only a subset of agencies identified vulnerable populations and/or adaptation activities to reduce heat-related human health risks. To this end, programs that predict and respond to excessive heat events are critical. EPA also emphasized the need to consider environmental justice concerns when assessing heat-related human health affects. For instance, low-income households may be at increased risk due to lack of air conditioning.

Hazard-related Human Health Concerns

Another climate change and health-related concern mentioned by several Federal agencies was the potential for increased on-the-job and disaster-related hazards. For example, DHS notes that climate change-related demands for increased presence in the Arctic will expose more employees to occupational hazards. In addition, USPS is concerned that flooding and extreme weather will result in increased hazards for postal workers while driving their routes. In many cases, the anticipated exposure of employees to more hazards translates into a training need regarding the appropriate steps to manage this type of impact (*see Section 2 on Communication*). In the case of USPS they also cited the need to “identify policies that cover heat and storm awareness” (USPS, p. 12). In addition to physical health concerns associated with hazards, some agencies also discussed the potential increase in mental trauma associated with natural disaster events. HHS is focusing their efforts in areas affected by severe weather events and areas experiencing long-term loss of habitability (such as in Alaska and along the Gulf Coast, HHS, p. 15). DOE discussed a need for mental health services that support the transition from short-term to long-term disaster recovery (Joplin Schools, DOE, p. 5).

The Role of Human Health in the Context of Multiple Stressors

Multiple stressors are known to interact with climate to influence the vulnerability of Earth systems, including humans systems. EPA, in particular, mentioned the need to better understand the human health effects of multiple interacting stressors. For instance, EPA cited the need to better understand how climate-related changes in sulfur, nitrogen, and mercury deposition patterns may affect ecosystem processes such as mercury methylation and bioaccumulation. Rising sea levels may increase mercury methylation (the microbial process by which inorganic mercury is converted to an organic form that more readily bioaccumulates) in newly flooded areas (UNEP 2013). Additionally, EPA cited a need to better understand the complex interactions between climate and the stratospheric ozone layer where harmful UV radiation is absorbed. For example, climate change can affect stratospheric ozone through changes in chemical transport, atmospheric composition, and temperature while stratospheric ozone can, in turn affect climate and weather (EPA, p. 16).

Understanding and Responding to Climate Change-related “Bio-Threats”

For the purposes of this analysis, a “bio-threat” refers to any unwanted natural, accidental, or deliberate biological event that threatens humans, livestock, or crops. Examples include the emergence of an infectious disease, the accidental release of a dangerous biological agent from a research lab, and bioterrorism. In August 2007, Congress established the National Biosurveillance Integration Center (NBIC) within DHS in order to improve the Nation’s capability to identify, characterize, localize, and track biological events. DHS NBIC cites the need to better understand “how climate change impacts may exacerbate conditions that influence or contribute to bio-threats” (DHS, p. 20). HHS also highlighted the need to better understand the complex interactions between changes in the climate and specific infectious diseases (to better anticipate predicted increases in water-borne and food-borne infectious disease, as well as changes in the distribution of vector-borne and zoonotic diseases).

Climate Change and Air Quality Interactions (Indoor and Outdoor)

EPA notes that the relationship between temperature changes and tropospheric ozone, a part of ground-level smog, are well understood. Climate change-induced high temperatures and air stagnation weather events could increase tropospheric ozone levels over broad areas of the country, the length of the ozone season, and individuals' vulnerability to air pollution (EPA, p. 14). EPA notes that these increases may make it difficult to attain or maintain current ozone standards. EPA also states a need for Federal, State, Tribal, and local governments to improve the effectiveness of existing emission control programs. While EPA states that the effect of climate change on particulate matter (PM) levels is less certain, they note that projected increases in U.S. wildfire frequency, severity, distribution, and duration may make it difficult for States to attain PM National Ambient Air Quality Standards (NAAQS) creating a need to better control and address regional transport of air pollution.

There was also a need to better understand how climate change will affect indoor air quality. EPA noted: "climate change may both worsen existing indoor environmental problems and introduce new ones as it alters the frequency and severity of adverse outdoor conditions" (EPA, p. 15). The effects of climate change on indoor air quality will vary depending on region and the age and condition of the structures. Examples include increased dampness and associated growth of mold and other biological contaminants, warmer temperatures and associated pest outbreaks leading to increased use of indoor pesticides, and more extreme weather/high temperatures leading to increased weatherization of buildings and an associated reduction in building ventilation (EPA, p. 15). GSA cited the need to better understand the sources of indoor environmental contaminants so that they can be controlled as risks emerge (GSA, p. 16). HUD also noted the need to improve their understanding of potential climate change impacts on indoor air quality and the likelihood that they will be region specific (HUD, p. 6).

CURRENT ACTIVITIES

Overall Human Health-related Climate Change Efforts

HHS is taking a number of steps to address human health-related climate change impacts. The CDC Climate and Health Program is working with other Federal agencies as well as State governments to identify and address human health concerns in climate change adaptation planning. The CDC Climate-Ready States and Cities Initiative is currently working with sixteen States and two cities to assess, plan, and implement health-related climate change adaptation programs (see Box 6). The CDC Building Resilience Against Climate Effects (BRACE) framework provides funding and a five step series of actions for State, territorial, and Tribal health departments to take in creating climate change adaptation plans. The USGCRP's Interagency Climate Change and Human Health Group (CCHHG) is another resource cited by agency adaptation plans and includes representatives from multiple Federal agencies including CDC, DHS, NIH, NOAA, EPA, and others. Among other things, this group reports on Federal research relating to the human health impacts of global change. In particular, a new Metadata Access Tool for Climate and

Box 6. Helping State and City Health Departments Plan and Prepare for Climate Change and Human Health Impacts

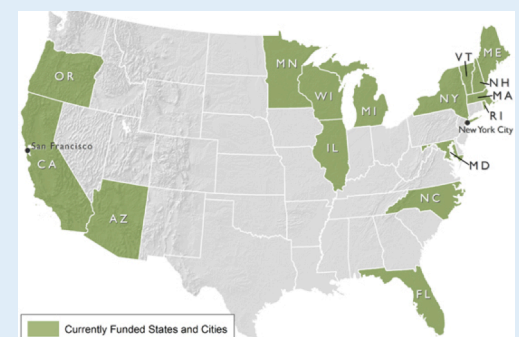
Background: The CDC Climate and Health Program has developed the Climate-Ready States and Cities Initiative to help state and city health departments plan and prepare for the health effects that climate change may have on people.

Adaptation Research and Information Need Addressed: The Climate-Ready States and Cities Initiative addresses the need for research and assessments of climate change and *human health* impacts.

Strategy: The Climate-Ready States and Cities Initiative is currently working with 16 states and 2 cities to assess, plan, and implement health-related climate change adaptation programs. Strategy development relies on the "Building Resilience Against Climate Effects" (BRACE) framework, a five step sequential process for developing successful human health-related climate change adaptation. The framework includes vulnerability assessment, projection of disease burden, identification of adaptation options, implementation, and evaluation.

Implications for Adaptation: This program has already helped 16 states and 2 cities on relevant health-related adaptation efforts. Many programs have focused on heat-related disease, vector-borne disease, respiratory disease, and extreme weather. This program will likely be relevant to other health departments and could potentially benefit governmental agencies as well.

Image 4: Map of Currently Funded States and Cities as Part of CDC's Climate-Ready States and Cities Initiative



Resource:
http://www.cdc.gov/climateandhealth/climate_ready.htm

Box 7. Guiding Health Officials and Others on Excessive Heat Event Preparedness and Response

Background: The Climate Change and Extreme Heat Events publication describes extreme heat events, how an extreme heat event threatens public health, and how to prepare for and respond to such an event. It explains how the frequency, duration, and severity of extreme heat events are increasing as a result of climate change, and includes links to local programs and real-world examples from across the country (p. 2).

Adaptation Research and Information Need Addressed: This publication provides guidance, information, and examples to inform *human health*-related impacts from climate change. It provides a comprehensive overview of understanding and responding to extreme heat events.

Strategy: This publication provides the latest research and facts regarding extreme heat events in a translated manner with examples of preparedness and response efforts around the U.S.

Implications for Adaptation: The materials found within this publication provide guidance for agencies to develop appropriate Extreme Heat Event (EHE) preparedness and response programs. Successful notification and response programs use sophisticated EHE forecasting technology in combination with their risk criteria to predict high risk EHEs. These programs then respond in a variety of ways. Examples of some responses include the notification of high-risk groups and individuals, the public distribution and broadcast of EHE-related information, and the designation of specific private buildings with air conditioning as public cooling shelters. While some U.S. cities like Philadelphia and Phoenix have already developed these programs, agencies cited a need for similar methods with which to assess and respond to heat-related health risks.

Image 5: The Climate Change and Extreme Heat Events Publication



Resource:

<http://www.cdc.gov/climateandhealth/pubs/ClimateChangeandExtremeHeatEvents.pdf>

Health (MATCH) serves as an online clearinghouse of publicly available Federal metadata that pertains to climate and health.

Heat Stress

As illustrated in **Box 7**, the CDC's "Climate Change and Extreme Heat Events" publication describes extreme heat events, how an extreme heat event threatens public health, and how to prepare for and respond to such an event. It explains how the frequency, duration, and severity of extreme heat events are increasing as a result of climate change, and includes links to local programs and real-world examples from across the country. This publication is an update to the 2006 "Excessive Heat Events Guidebook" that EPA, CDC, NOAA, National Weather Service (NWS), and DHS partnered together on this resource for agencies who are interested in assessing the vulnerability of their employees to heat stress (EPA 2006).

While many agencies stated the need to assess the vulnerability of their employees to heat stress, HUD's adaptation plan provides a useful example of a heat stress vulnerability analysis. The report analyzes the vulnerability of both HUD employees and public housing/multi-family properties.

Environmental Justice-related Human Health Concerns

In an effort to address environmental justice-related human health concerns, the Federal Interagency Working Group on Environmental Justice (EJ IWG) supports the development of "strategies to identify and address disproportionately high and adverse human health or environmental effects" (HHS, p. 20) of agency programs on minority and low-income populations.

Climate Change and Human Health Research Activities

The NIH funding program, Climate Change and Health: Assessing and Modeling Population Vulnerability to Climate Change, is aimed at understanding the health impacts of climate change, and how strategies used to adapt to or lessen climate change might affect health adversely or provide health co-benefits. This research, led by NIEHS, is helping to identify vulnerable populations, produce methods and models for studying climate change effects, and advance knowledge about how to best communicate risks of climate change and how to prepare and adapt to them.

PLANNED ACTIVITIES

A number of Federal agencies are planning adaptation activities that address climate change and human health concerns. DOC is planning to

address the need to understand where in the U.S. climate change-related health impacts are currently occurring. They plan to approach this question through an economic lens by expanding information on health care spending to help

quantify increased costs stemming from climate-change related illness. DOEd is planning to address the need for bio-threat response by developing infectious disease plans under the Readiness and Emergency Management for Schools (REMS) program. HUD is planning to address indoor air quality as part of their strategic goal to “utilize housing as a platform for improving quality of life” (HUD, p. 6). HHS is planning to address disaster-related mental health issues by working with the Assistant Secretary for Preparedness and Response. Several agencies are planning to address hazard-related human health concerns as well. For instance, DHS is anticipating an increased need for more personnel in high latitude operations and is planning to develop “appropriate doctrine and a training program for its Arctic operations” (DHS, p. 28). Similarly, USPS is planning to ensure that heat and storm-related “warning systems and emergency procedures are in place for employees” (USPS, p. 12).

OPPORTUNITIES FOR COLLABORATION

In many cases human health-related adaptation activities will require inter-departmental collaboration. HHS is hoping to collaborate with other Federal agencies that manage health care facilities (such as VA, DoD, and FEMA) to form integrated climate adaptation strategies. HHS is also considering expanding its current interagency collaboration on healthy communities, schools, housing, and transportation (with EPA, HUD, DOT, USDA and others) to take climate change into account. In addition, HHS identified DOL, DHS, and HUD as potential collaborators in efforts to manage human service systems during weather disasters. Finally, HHS is working with DHS and DoD on a National Health Security Strategy.²⁶

4. Natural Resources

OVERVIEW

Natural resources support the Nation’s built infrastructure and can provide a critical buffer between the built environment and the effects of climate change. For example, coastal vegetation can buffer some storm surges; agricultural cover cropping can reduce topsoil loss during storm events; and forest management techniques can reduce wildfire risk. Natural resources also support the harvest and use of important consumptive resources like clean water, crops, and fisheries. Finally, the conservation of biodiversity and ecosystem health supports recreation, learning, and scientific exploration for future generations. Climate change will affect a number of the ecosystem services we gain from natural resources. Ocean acidification threatens the sustainability of shellfish industries,²⁷ melting sea ice causes changes in the distribution of important Arctic fishery stocks,²⁸ rising temperatures amplify problems associated with managing livestock heat stress,²⁹ and changes to the hydrologic cycle result in water quantity and quality problems.

The need for research and information to inform natural-resource adaptation efforts was not identified as frequently throughout all of the agency plans but stood out in plans from specific agencies mission areas around certain types of natural infrastructure. For instance, the DOC emphasized a need to understand and manage coastal impacts from climate change due to NOAA’s role in this field. DHS was particularly interested in gaining an increased understanding of changes in the Arctic due to the important role of the U.S. Coast Guard in international waters. The USDA emphasized the need to improve their understanding of changes in pests and pathogens and how they will affect agricultural systems. The DOI noted the need to identify (and protect) resilient ecosystems, habitat corridors, and climate refugia (DOI, p. 5). In other words, there is a need to ensure that species will have access to suitable habitats

²⁶ Department of Health and Human Services. *National Health Security Strategy of the United States of America*. December 2009. Website: <http://www.phe.gov/preparedness/planning/authority/nhss/strategy/documents/nhss-final.pdf>

²⁷ U.S. Global Change Research Program. *Global Climate Change Impacts in the United States*. 2009: p. 149. Website: <http://downloads.globalchange.gov/usimpacts/pdfs/climate-impacts-report.pdf>

²⁸ U.S. Global Change Research Program. *Global Climate Change Impacts in the United States*. 2009: p. 85. Website: <http://downloads.globalchange.gov/usimpacts/pdfs/climate-impacts-report.pdf>

²⁹ U.S. Global Change Research Program. *Global Climate Change Impacts in the United States*. 2009: p. 78. Website: <http://downloads.globalchange.gov/usimpacts/pdfs/climate-impacts-report.pdf>

as the climate changes. Finally, several agencies noted the disproportionate impact of changes to natural resources in Native American groups as well as the potential value of incorporating traditional ecological knowledge when considering climate change adaptation options (EPA and DOI). The following sections describe the research and information needs highlighted by agency adaptation plans broken out by the type of natural resources of interest instead of status of the action.

RESEARCH AND INFORMATION NEEDS INCLUDING CURRENT AND PLANNED ACTIONS

Coastal and Oceanic Research and Information to Inform Adaptation Actions

Storm surges, rising sea levels, ocean acidification, salt water intrusion, and overall ecosystem resilience were all vulnerabilities highlighted in agency adaptation plans that addressed coastal adaptation. In April 2013, the NOC released the National Ocean Policy Implementation Plan, a document that describes specific actions Federal agencies will take to address key ocean challenges and includes a section on climate change. The implementation plan addresses some key science needs identified in agency adaptation plans including the need for better forecasting of ocean conditions and events along with the need for improved data on severe storms and sea level rise. NOAA is already providing a number of scientific services to help inform coastal adaptation including, but not limited to:

- (1) Information and services on coastal acidification for sectors like the West Coast oyster industry (DOC, p. 6);
- (2) Collaboration with USACE and others on the Digital Coast web-based tool for scenario-based sea level rise planning; and
- (3) Development of climate change guidance relating to land acquisition and investments made through the Coastal and Estuarine Land Conservation Program and Coastal Zone Management Act program partnerships (DOC, p. 14).

NASA is particularly focused on the vulnerability of coastal dunes (due to the location of the Kennedy Space Center) and has a Dune Vulnerability Team that focuses on the protection and restoration of beach dunes (NASA, p. 9). DoD also has projects that deal with climate impacts on coastal ecosystems because “the military’s long-term use of costal installations is, in part, dependent on the ability to maintain the continued functioning of coastal ecosystems” (DoD, p. 7). Scientists also anticipate large climate-related impacts on fishery resources thus demanding a better understanding of the environmental, economic, and social impacts of climate change impacts on fisheries. NOAA notes that changing ocean conditions will affect the distribution and abundance of fish stocks with implications for “the timing, effort, and location of fish stock survey and fisheries enforcement” (DOC, p. 13). Also, Oregon State University’s Parameter-elevation Regressions on Independent Slopes Model (PRISM) Climate Group is partnering with USDA to build a Climate and Weather web portal that will be used by risk management and crop insurance providers and can also be used by producers to make planting and production decisions.

Arctic Research and Information to Inform Adaptation Actions

Multiple agencies identified the need to better understand changes in the pattern and extent of both sea ice melt and permafrost thawing. The thawing of permafrost will present infrastructural, cultural, and environmental concerns. The EPA is concerned that “thawing could allow contaminants to migrate more freely to adjoining areas” (EPA, p. 21). The USPS, on the other hand, is concerned about changing accessibility of northern roads due to permafrost thawing. Similarly, DoD is currently assessing its Arctic observing, mapping, and environmental prediction capabilities in order to better anticipate and identify its science and technology needs. Finally, DOI noted that thawing permafrost and melting sea ice may threaten the livelihoods of Alaska Natives. In terms of sea ice melt, agencies noted a need to better understand and respond to changes in the distribution of fish and protected species in the Arctic (NOAA fish stock surveys, USCG enforcement concerns). To address this need, NOAA is planning to add to their Arctic monitoring program by deploying six biophysical moorings in the Arctic. They also plan to complete their “northern extension” of the Bering Sea bottom trawl survey for groundfish and invertebrate resources (*see Observations and Monitoring in*

Section 7 and Box 12). Finally, as sea ice melt continues, DHS called for international collaboration among Arctic Nations (U.S., Canada, Denmark, Finland, Iceland, Norway, Russian Federation, and Sweden) regarding the potential for increased boat traffic in the Arctic.

Agricultural Research and Information to Inform Adaptation Actions

While several agencies cited the need to incorporate changes in agricultural production patterns into their adaptation plans, the USDA adaptation plan provided a large amount of detail identifying specific science needs related to agricultural production infrastructure (USDA, p. 13). The dominant areas of high science needs identified include:

- (1) Improved management strategies and technologies for monitoring and reducing livestock heat stress;
- (2) Better techniques to reduce agriculture-related water use;
- (3) Development of genetically engineered crops that are better adapted to climate change;
- (4) Enhanced understanding of how climate is currently integrated into conservation activities;
- (5) Improved understanding of how climate variability is already affecting agricultural and natural resource management;
- (6) Understanding of the effects of climate change on pests and pathogens; and
- (7) Improved pesticide management techniques.

EPA also noted the likelihood that increased pest problems will lead to a need for improved pesticide management. More specifically, EPA noted that the need for emergency exemptions under the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA) could increase, allowing “for the use of chemicals which are not registered” (EPA, p. 23). In order to better identify and address research and information related to these possible future needs, the USDA National Institute of Food and Agriculture (NIFA) is planning to establish a Science Priority-making Process for Climate Change in order to “identify and manage a set of core climate change activities that cuts across agency programs and portfolios and would function as the central source of management for climate change research, education and extension activities” (USDA Appendix A, p. 81).

General Terrestrial Ecosystem Research, Information, and Management to Inform Adaptation Actions

The USDA Forest Service (USFS) emphasized the need “to increase understanding of forest, woodland, and grassland ecosystems so that they can be managed in a way that sustains and provides ecosystem services for future generations” (USDA Appendix A, p. 60). With regard to site-specific management, EPA is concerned about how changes in climate may influence various cleanup remedy efforts. There is a need to quantify the site-specific climate change impacts on Brownfields, Superfund sites, Treatment, Storage, and Disposal (TSD) facilities, non-hazardous solid waste facilities, Leaking Underground Storage Tanks (LUST), Corrective Action Facilities under the Resource Conservation and Recovery Act (RCRA), and RCRA treatment (EPA, p. 13). The climate change impacts on these facilities will vary depending on both the region and the nature of the cleanup. Examples include the mobilization of contaminants via thawing permafrost (described above), ineffective water intensive cleanup remedies in drought-ridden areas, and volatilization of contaminants via high temperatures, dry conditions and/or wildfire. Overall, there is a need to better predict and respond to these changes.

Species-based Research and Information to Inform Adaptation Actions

Climate change can directly affect species distributions via climate-induced migration and/or extirpation and can also work in concert with non-climate change stressors to improve species vulnerability. DOI notes the need to identify and reduce non-climate change stressors that interact with climate change. Examples of non-climate change stressors include habitat fragmentation, invasive species, and land use change. More specifically, DOI noted the need to monitor invasive species (which they define as “alien species that cause negative economic, environmental, or human health impacts”). They also cite the need to coordinate with other agencies to develop and implement programs to

stop the spread of invasive species and the introduction of new invasive species. EPA also mentions the potential for climate change to increase the risk from invasive species to water and waste water systems. The concern for protecting species and habitat diversity is echoed by USDA USFS's efforts to prioritize forest trees for gene conservation as part of their Forest Health Protection program (FY12-15). In addition, there is a need to better understand and respond to species-specific impacts that threaten the livelihoods of native people and indigenous communities (DOI, EPA). For instance, EPA highlighted the climate-related declines in moose in the Great Lakes region and DOI highlighted the potential migration and extirpation of plant and animal species important to native people. Species-relevant climate change adaptation strategies are currently laid out in the document "National Fish, Wildlife and Plants Climate Adaptation Strategy." The strategy is a first-of-its-kind blueprint for coordinated Federal, State, Tribal, and non-governmental adaptation action related to fish, wildlife, and plants. Goal 5 of the strategy addresses information and knowledge needs (see Box 8).

Freshwater Research and Information to Inform Adaptation Actions

In October 2011, the Interagency Climate Change Adaptation Task Force published a National Action Plan entitled "Priorities for Managing Freshwater Resources in a Changing Climate" (ICCATF 2011). Its priority recommendations included expanding water use efficiency, supporting Integrated Water Resources Management (IWRM), and improving the ability to assess the impacts of climate change on water resources. These needs were reiterated in many of the agency adaptation plans. Specific freshwater adaptation science needs identified in the plans are described below.

Water Quality—Given the impacts of climate change on the quality of water across the Nation, the need to improve the understanding of environmentally and economically sustainable water treatment options was mentioned by a number of agencies. EPA anticipates an increased demand for water testing and treatment due to:

- (1) Higher air and water temperatures promoting increased algal and microbial growth;
- (2) Shifting precipitation regimes causing increases in storm water runoff and associated sediment and contaminants;
- (3) Saltwater intrusion encroaching on coastal drinking water supplies; and
- (4) Reduced availability of snowmelt-fed surface water supplies resulting in increased reliance on previously untapped aquifer supplies (EPA, p. 19-20).

Box 8. Planning Strategically for Effective Adaptation Actions to Sustain Fish, Wildlife, and Plants at Multiple Scales

Background: Climate change will act as a threat multiplier for many species. The National Fish, Wildlife, and Plants Climate Adaptation Strategy is a first-of-its-kind document that provides a blueprint for fish, wildlife, and plant adaptation action at Federal, State, Tribal, and local levels.

Adaptation Research and Information Need Addressed: The development of this national adaptation strategy addresses the need for science to inform decisions on *natural infrastructure*. In particular, the strategy identifies consensus-based best practices for natural resource adaptation.

Strategy: The Strategy was called for by Congress as part of the Fiscal Year 2010 Department of the Interior, Environment and Related Agencies Appropriations Act Conference Report. In addition, the Strategy was recommended by the Interagency Climate Change Adaptation Task Force in the [2010 Progress Report](#). In response, NOAA, USFWS, and the State of New York co-chaired the effort to compile the National Fish, Wildlife, and Plants Climate Adaptation Strategy. A steering committee composed of representatives from 15 federal agencies, 5 states, and 2 intertribal commissions helped guide the development of the document and the implementation of the strategy.

Implications for Adaptation: The strategy aims to provide natural resource decision makers with sensible climate change adaptation actions that can be taken now as well as guidance regarding adaptation measures to safeguard against future impacts. Goal 5 of the strategy is to "increase knowledge and information." This includes the need to continue to identify knowledge gaps, the need to identify (and reduce) non-climate stressors, the need to obtain climate information at a variety of scales, the need for models that can predict changes at small regional scales, the need for models that predict changes in species distribution, and the need to better understand the adaptive capacity of species, communities, and ecosystems.

Image 6: National Fish, Wildlife, and Plants Climate Adaptation Strategy



Resource: In addition to the full report, their website provides a general factsheet, examples of adaptation efforts, and additional resources (<http://www.wildlifeadaptationstrategy.gov>). In addition, a recent webinar describing the strategy can be found online at <http://bcove.me/yr0sfwtg>

Flooding events can also cause water quality concerns due to the increased incidence of water-borne pathogens (like *Giardia* and *Cryptosporidium*), and sewage overflow problems associated with these events (HHS, DOT, TVA). HUD reiterated the need to focus on water treatment facilities and options. They highlighted the Houston/Galveston region

for the work they are doing to use green infrastructure that will address water quality and water flooding issues (HUD, p. 32). The cities of Cincinnati and Pittsburgh were also highlighted for “exploring environmentally and economically sustainable alternatives to wholesale infrastructure overhaul to separate combined sewer overflows to better manage rainfall in large storm events” (HUD, p. 32).

Box 9. Collaborating to Improve the Management of Water Resources in the Ohio River Basin

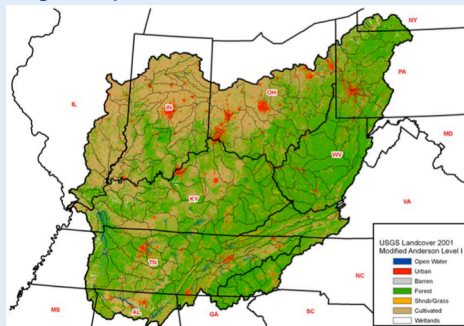
Background: The Ohio River Basin Alliance (ORBA) relies on collaboration from over 80 governmental and non-governmental partners and aims to improve the management of water resources in the Ohio River Basin. The CEQ's Integrated Water Resources Management Team selected the ORBA's pilot Climate Change Study for funding, and collaborate work to identify climate change impacts in the Ohio Valley began in July 2012.

Adaptation Research and Information Need Addressed: The ORBA Climate Change Study addresses the need for science to inform decisions on *natural and built infrastructure* as well as the need for *regional climate change information*.

Strategy: USACE plans to work with ORBA to develop best practices for supporting an IWRM framework for climate change adaptation.

Implications for Adaptation: This type of pilot study provides valuable insights into the capacity of IWRM methods to address the needs of water resource operating projects. Water resource project operations are unique in their need to be continuously implemented (to meet water supply, hydropower, navigation and other demands).

Image 7: Map of the Ohio River Basin Land Cover



Resource: <http://www.ohioriverbasin.org>

Water Quantity—DOI cited the need to “expand and encourage efficiency measures for water and energy use” (DOI, p. 6). Many techniques for increasing water use efficiency already exist, including, but not limited to, installing flow restrictors/aerators on faucets, installing low flush volume devices on toilets, water reuse for cooling towers, and storm water detainment for onsite irrigation. However, the USDA does reiterate the need for improved water efficiency measures. DOE noted vulnerability from “operational and budget impacts due to magnified water and energy/electricity shortages and/or prolonged droughts” (DOE, p. 6). Many other agencies note the need for their own agency, or water suppliers in general, to pursue water conservation options (EPA, NARA, DoD, DOL, GSA, HHS, NASA, NCPC, and USACE). In the case of DOT, water shortage was more of a concern for its impacts on navigable waterways. Other agencies are focused on how to adjust water management practices to respond to shifts in water supply (USACE, TVA). In the case of flooding, there is a need to better understand and quantify the potential impacts to water infrastructure that is pushed beyond its intended capacity (EPA and USACE). Several agencies, including: USACE, DOI, USGS, USDA, NRCS, EPA, NOAA, and USFS are working on developing benchmarks for incorporating adaptive management into water project designs, operational procedures, and planning strategies.

Basin-wide approaches—On a broader scale, DOI states the need to “employ a basin-wide approach” and to “strengthen and enhance assessments of vulnerability of water resources to climate change” (DOI, p. 6). The need for basin-wide water resources management has resulted in a number of pilot studies by USACE that support IWRM. In particular, the West Maui Watershed Study and the Ohio River Basin Alliance are both Federal/non-Federal partnerships that are working to incorporate IWRM into watershed-scale climate change adaptation planning (see Box 9).

Additionally, one of USACE’s planned action items is to work closely with States “to identify flood risk and management ‘best practices’ to prepare for hydrologic extremes” (USACE, p. 11).

Climate and Water Interactions—A number of agencies mentioned the overarching need to better understand the climate and water interactions. CCAWWG is an interagency effort that is working toward this end. It provides scientific and engineering collaboration opportunities to support water management under a changing climate. The Workgroup

helps to identify shared priorities and leverage resources across Federal agencies to meet common needs (both understanding how future climate variability will affect hydrologic conditions and identifying potential adaptation strategies). One recent product prepared by the group is an online training for water resource planners, engineers, practitioners, and technical specialists that focuses on how to prepare hydro-climate inputs for incorporating climate change into water resources planning. There is also a collaborative effort between USACE, DOI's Bureau of Reclamation, and UCAR's COMET program to produce training materials for professionals facing questions of climate change and water resources (*see the Regional Climate Information and Modeling in Section 6*).

OPPORTUNITIES FOR COLLABORATION

The Urban Waters Federal Partnership is an example of a collaboration that may provide the capacity for adaptation-related water resource management. This partnership is coordinated by the White House Domestic Policy Council, and includes representatives from USDA, USACE, DOC, DOE, DoE, EPA, HHS, HUD, DOI, DOT, and the Corporation for National and Community Service. It aims to improve collaboration between Federal agencies and urban community-led revitalization efforts to improve the Nation's waters by promoting their economic, environmental and social benefits (clean, safe, and accessible waters). The project focuses on economically distressed communities and has identified seven pilot locations: Anacostia Watershed (Washington DC/Maryland), the Patapsco Watershed (Baltimore, Maryland), Bronx and Harlem River Watersheds (New York), South Platte River (Denver, Colorado), Los Angeles River Watershed (California), Lake Pontchartrain Area (New Orleans, LA), and the Northwest Indiana Area.

5. Disaster Response

OVERVIEW

Climate change is expected to result in an increase in the frequency and severity of extreme weather events. Climate change may also result in shifting patterns in the regional distribution of these events.³⁰ While a number of Federal agencies are already tasked with addressing various aspects of disaster response, all agencies have the potential to be affected by these changes during extreme weather events.

Because government agencies have been responding to natural disasters for a long time, research and information needs related to disaster response are largely centered on the understanding of how the frequency, intensity, and spatial patterns of natural disasters will change over time and locale. This includes the need for improved models of future hazards and the need to conduct exercise scenarios to test the potential for certain actions that will improve emergency preparedness. Disaster response is inherently a collaborative endeavor, so the need for collaboration will also be crucial in achieving effective adaptation.

RESEARCH AND INFORMATION NEEDS

Modeling of Future Hazards and Natural Disasters

Incorporating climate change into existing risk models remains a challenge (*see the Regional Climate Information and Modeling Section 6*). The need to appropriately model future hazards/natural disasters came up in several agency plans (DHS, USACE). For instance, hydrologic modeling of flood events will need to be updated to consider climate change impacts. USACE is taking a number of approaches to address this challenge. They are currently in the process of developing an Engineering Technical Letter in the Global Change Series entitled "Appropriate Use of Paleoflood Hydrology for Civil Works Programs." The document develops guidance on how to "utilize information from the very distant past to help frame characteristics of flood possibilities" (USACE, p. 24). They are also in the process of updating their inland hydrology guidance "to address climate impacts to the hydrologic aspects of USACE projects and programs"

³⁰ U.S. Global Change Research Program. *Global Climate Change Impacts in the United States*. 2009: p. 32-33. Website: <http://downloads.globalchange.gov/usimpacts/pdfs/climate-impacts-report.pdf>

(USACE, p. 24). In addition, DHS plans to continue to study the impacts of climate change on the National Flood Insurance Program (NFIP). An initial 2-year study “concluded that climate change is likely to have significant impacts on the NFIP.” DHS’s continued study will include an effort by FEMA to identify areas where future climate should be considered as part of the larger effort to reform the NFIP (DHS, p. 33). Challenges associated with inland hydrologic modeling under a changing climate are also being addressed by the CCAWWG discussed above.

The need to anticipate and plan for the potential impacts of natural disasters is also important to address. DHS has already developed models that simulate the impacts of natural disasters. FEMA’s HAZUS framework and model provides a standardized methodology for estimating losses from earthquakes, floods, and hurricanes. The GIS-based model can be applied pre or post hazard to estimate social impacts (shelter requirements), economic impacts (cost to rebuild, loss of jobs), and impacts to essential facilities (hospitals, fire/police stations, and schools). While the model can be extremely helpful, DHS notes the potential danger of continuing to use historical records to predict the magnitude, location, and frequency of future hazards. To this end, DHS plans to work with NOAA and stakeholder organizations “to help refine the input data used to support complex event modeling, hazard identification, and risk assessment processes to improve analytical results” (DHS, p. 27; also described in *Section 6 Regional Climate Information and Modeling*). In addition, the DOS identified the need to continue integrating climate change considerations into its efforts to explore the risks posed by extreme weather events via the Natural Hazards Program.

Assessment of Specific Actions to Improve Emergency Preparedness

Once vulnerabilities to a natural disaster have been identified, there is also a need to conduct exercise scenarios to test the potential for certain actions to improve emergency preparedness. DOC plans to address this need by developing facilities and software that can test infrastructural stability in the face of extreme weather events (see *Section 1 on Built Infrastructure*). Other than DOC’s plans, there were few citations of similar efforts to conduct exercise scenarios. Despite the lack of exercise scenario approaches, it may be fruitful to consider previous disaster and recovery efforts when planning for potential future impacts. The Citizen’s Advisory Recovery Team (CART) is one example of a community-based effort to respond, recover, and rebuild after a natural disaster (see **Box 10**). For this effort, citizens and community leaders from Joplin, MO partnered with FEMA, HUD, EPA and others to recover from the impacts of a catastrophic tornado that hit their town in 2011. Similarly, the recovery efforts associated with Hurricane Sandy may provide another good case study for considering what works and what doesn’t. While Sandy occurred after the agency adaptation plans were submitted, the Hurricane Sandy Rebuilding Task Force (established by Executive Order in December 2012) provides an example of a strong effort to coordinate and support rebuilding objectives. For more information on the Sandy Task Force, see:

http://portal.hud.gov/hudportal/HUD?src=/press/press_releases_media_advisories/2013/HUDNo.13-125

In addition, some Federal efforts are underway to assess the preparedness of social and built infrastructure to natural disaster impacts. The Interagency Performance Evaluation Task Force/Hurricane Protection Decision Chronology Lessons Learned Implementation Team (also known as Actions for Change) aims “to provide credible and objective scientific and engineering answers to fundamental questions about the performance of the hurricane protection and flood damage reduction system[s]” (USACE, Chief of Engineers). The National Health and Security Strategy is also currently under development by HHS, DHS, and DoD. This document presents a framework for how to protect people’s health in the case of an emergency, including a description of the current challenges and gaps in the overall approach.

OPPORTUNITIES FOR COLLABORATION

Throughout the Federal government, there is a strong need for interagency collaboration when planning for future increases in disaster response demands. DHS noted, “adaptation strategies implemented by external partners and stakeholders will affect how DHS/FEMA meets its mission of ensuring resilience to disasters” (DHS, p. 32). Several interagency collaborative efforts on disaster relief efforts already exist. For example the IRS provides free tax assistance at FEMA Disaster Recovery Centers, and the CDC distributes vaccinations through IRS offices during a pandemic. A number of agency plans suggested the potential for future collaborations in addressing disaster response. For instance, HHS is considering collaborations with DOL, DHS, and HUD to share information on managing human service systems to respond and recover from disasters.

6. Regional Climate Information and Modeling

OVERVIEW

The specific impacts and vulnerabilities posed by climate change are largely defined by regional differences³¹ in things like geography, climate, ocean currents, and land use change. For example, regional differences in hydrology (snow-melt dominated vs. monsoon dominated vs. runoff dominated) will be important in defining and responding to climate change-related shifts in water supply. Regions of extensive urban development are more vulnerable to heat island effects and flash flooding whereas regions of extensive agricultural development may be especially vulnerable to shifts in precipitation patterns and related shifts in irrigation demands. Even coastal concerns will vary largely by region. For instance, zones of ocean upwelling along the west coast of North America will likely experience disproportionate ocean acidification compared to the east coast of North America.³²

RESEARCH AND INFORMATION NEEDS

Many agency adaptation plans stated a need for more region-specific information about climate change impacts. This includes the need for improved event forecasting, weather forecasting, and scenario-based impact projection capabilities on relevant scales. It also includes regionally relevant and spatially explicit information like data on heat stress, air quality, drought, flood, wildfire, and sea level change risks, among others. A number of challenges arise when new climate information must be incorporated into older models, especially when the original model does not contain a climate component. In the case of agricultural systems, modeling the effects of climate change on cropping times becomes difficult when models are forced to extrapolate outside the time frame for which they were originally intended (USDA

Box 10. Empowering Citizen's Advisory Recovery Team to Identify Disaster Response and Recovery Needs

Background: The Citizen's Advisory Recovery Team (CART) is a group of city officials, business leaders, community leaders, and citizens that formed in Joplin, MO in response to the catastrophic tornado that hit their town in May 2011.

Adaptation Research and Information Need Addressed: CART addresses the need for *disaster response* and will likely lead to the development of best practices for *built infrastructure* redevelopment on a community level.

Strategy: With support from FEMA's Long-Term Recovery Task Force, HUD, EPA, and the American Institute of Architects, CART conducted public input and community sessions to identify recovery needs. The group now addresses issues in four main sectors: economic development, school and community facilities, housing and neighborhoods, and infrastructure and environment. The Department of Education is planning to use this input to examine the role of schools in addressing emergency management.

Implications for Adaptation: CART aims to “set the standard for disaster recovery.” They support and encourage adaptation-friendly planning including the use of sustainable, energy efficient building techniques, improved water management programs, the development of strategies for enforcing existing housing codes, and the consideration of underground utilities.

Image 8: Joplin, MO Citizen's Advisory Recovery Team (CART) Positive Messaging for Disaster Recovery



Resources: www.joplinareacart.com

³¹ U.S. Global Change Research Program. *Global Climate Change Impacts in the United States*. 2009: p. 12. Website: <http://downloads.globalchange.gov/usimpacts/pdfs/climate-impacts-report.pdf>

³² U.S. Global Change Research Program. *Global Climate Change Impacts in the United States*. 2009: p. 151. Website: <http://downloads.globalchange.gov/usimpacts/pdfs/climate-impacts-report.pdf>

Box 11. Supporting the Development of Innovative, Interdisciplinary, User-inspired, and Regionally Relevant Research to Inform Climate Adaptation Efforts

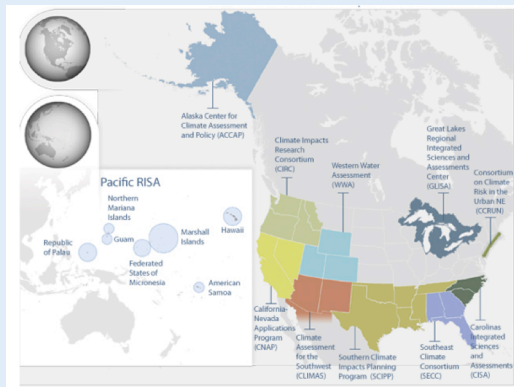
Background: The Regional Integrated Science & Assessment (RISA) program aims to support the development of innovative, interdisciplinary, user-inspired, and regionally relevant research to inform climate change adaptation efforts. RISA is funded by NOAA's Climate Program Office and is one of five programs covered by the "Climate and Societal Interactions" directorate.

Adaptation Research and Information Need Addressed: RISA addresses the need for *regional climate information and models*. Each region-specific program looks a little bit different and addresses different additional science needs laid out in this report (see examples below).

Strategy: RISA funds research teams to help develop capacity for regional climate change planning and adaptation. RISA focuses on 11 regions within the US (see map below) and supplements research efforts with outreach to public and private user communities.

Implications for Adaptation: Projects funded under RISA will provide actionable science that is useful at regional scales. Current projects include the development of an interactive Alaska Sea Ice mapping database, a tool that predicts the probability of different types of weather/climate-related public health emergencies in the Carolinas, an analysis of different policy options for reducing dust production on the Colorado Plateau, a project that works to incorporate indigenous environmental knowledge into climate adaptation in Hawaiian communities, and a project that links global climate models to regional hydrologic models to better anticipate changes in surface water and groundwater supply in the Central Valley of California.

Image 9: Map of NOAA RISA Program Teams in the U.S.



Resource:

<http://cpo.noaa.gov/ClimatePrograms/ClimateSocietalInteractionsCSI/RISAProgram.aspx>

ARS, p. 70). Water resource modeling can also face challenges when existing hydrologic models are combined with different climate projections. USACE noted the need to “identify and explain issues associated with model resolution and regionalizing, especially with respect to downscaling and bias correction” (USACE, p. 25). More generally, a number of agency plans emphasized the need for a means of accessing the most up to date regional scientific data on potential future climate change conditions and impacts.

CURRENT ACTIVITIES

Conducting Region-specific Analysis and Research to Inform Adaptation

Several agencies are already conducting region-specific analyses to inform climate change adaptation. NOAA's six Regional Climate Centers (RCC) are Federal-State cooperatives producing and delivering useful regional climate data (including regional climate outlook products) for the Western, High Plains, Midwestern, Southern, Southeast and Northeast regions. NOAA also has the Regional Integrated Sciences and Assessments (RISA) Program supporting development of adaptation information and tools in 11 different regions throughout the U.S. (see Box 11). DoD is engaged in two Federal-state partnerships; the Western Regional Partnership broadly aims to improve regional sustainability whereas the Southeast Regional Partnership for Planning and Sustainability (SERPPAS) is particularly active in supporting projects that aim to improve understanding of regional climate change impacts and adaptation strategies. DOT's Gulf Coast Study represents another regional effort that examines how changes in climate over the next 50-100 years could affect transportation systems in the U.S. Gulf Coast region. Phase I of the study was completed in 2008 and Phase II is ongoing. On a smaller scale, Secretarial Order No. 3289 established the DOI supported Landscape Conservation Cooperative (LCC), a network of 22 landscape-scale public-private partnerships across the country. LCCs are a forum for States, Tribes, Federal agencies, and NGOs to work together and “identify regional best practices, connect efforts, identify gaps, and avoid duplication through improved conservation planning and design.”³³

PLANNED ACTIVITIES

Plans to Improve Accessibility of Regional Climate Change Research and Information

In January 2013, an independent Federal advisory committee released a draft version of the Third National Climate Assessment (NCA) Report, along with its first set of standardized regional climate scenarios. These scenarios summarize

³³ Department of the Interior - U.S. Geological Survey. *Landscape Conservation Cooperatives*. Website: <https://nccwsc.usgs.gov/content/landscape-conservation-cooperatives-lccs>

the observed and anticipated changes in the climate for each of the eight NCA regions of the U.S., as well as on Oceans and Coasts. The regions include: Northeast, Southeast, Midwest, Great Plains, Northwest, Southwest, Alaska, and Hawai'i/Pacific Islands. Each of the eight NCA regional chapters were informed by the NCA Regional Climate Scenarios that were released in January 2013. Many agencies mentioned plans to use the NCA documents, and it is hoped that these scenarios will go a long way in addressing the demand for region-specific information. EPA has already collaborated with NOAA and USGCRP in the development of a pilot webcast to train EPA and DOI employees as well as outside entities in the use of these scenarios. They focused on two case studies that highlighted regional climate change trends (historic) and projections (future) in the Northeast and Southwest Regions. EPA has links to webinar presentation slides, transcripts, and podcasts that may be useful to regional decision makers. USGCRP is planning to produce short summaries of the lengthy 80-page Regional Climate Scenarios that will be translated into terms that are understood by multiple users of the scenarios. They are also looking to collaborate with other agencies to create additional region-specific webinars.

In addition, the USGCRP also plans to incorporate regional climate information into a web-based information system that is expected to go online in Spring 2014 and will contain all of the data and information that underpins the Third NCA. The NCA will also include a dedicated chapter about adaptation.

Other plans to expand the accessibility of regional climate information include the DOI's plans to expand their National Climate Change and Wildlife Center to include a series of eight regional Climate Science Centers (CSC). The CSCs will function to provide relevant climate science data to managers of land, water, wildlife, and cultural resources and will prioritize data needs based on input from the LCCs. One of DOE's overarching Multi-Year Climate Change Adaptation Goals and Objectives is to "work with other Federal agencies and local jurisdictions (as appropriate) to develop regional partnerships for climate change information sharing and collaboration" (DOE, p. 11). DOT also has a Transportation and Climate Change Clearinghouse website at www.climate.dot.gov. In addition, USDA recently released plans to build on the existing network of Federal climate science research and action centers with the creation of seven new Regional Climate Hubs to deliver tailored, science-based knowledge to farmers, ranchers, and forest landowners. These hubs will work with universities and other partners, including DOI and NOAA, to support climate resilience.

Plans to Improve Regional Models

The DHS Science and Technology Directorate is planning to coordinate with NPPD, NOAA, and stakeholder organizations to improve input datasets that will support more accurate forecasts of climate change-related hazards (DHS p. 27; also described in *Section 5 Disaster Response*).

OPPORTUNITIES FOR COLLABORATION

Federal and non-Federal programs are building capabilities and providing capacity to support decision makers with actionable information for climate adaptation. NOAA's RISA teams build capabilities to understand how actionable information for climate adaptation can be developed, while the NOAA Regional Climate Services Directors (RCSD) and RCC provide ongoing support for decision makers, particularly in the coastal and marine sectors. DOI's Climate Science Centers (CSC) provide capacity to produce actionable climate information both for ecosystem managers participating in the network of LCC and for other DOI bureaus. The USDA's Cooperative Extension System and the Forest Service's Research Stations are drawing on the RISAs, RCSDs, CSCs and LCCs to better serve land manager's needs for climate information. The USDA Regional Climate Hubs program is also planning to build on the existing network of Federal climate science research and action centers with the creation of their seven new Regional Climate Hubs.

CDC's Climate-Ready States and Cities Initiative to help state and city health departments plan and prepare for the health effects that climate change may have on people is likely to be informed by these other regional efforts. Coordination and collaboration between all of these efforts and other Federal agency-supported regional initiatives is critical to get the science and information to those who are adapting at the regional and local levels. In addition, in an effort to not duplicate efforts and truly leverage the capabilities and resources of multiple agencies for a more resilient Nation, collaboration amongst the Federal agencies and their regional efforts is very important. The USGCRP ASIWG can act as a convener and integrator of these regional efforts so as to achieve an effective regional network of science, tools, and resources.

7. Observations and Monitoring

OVERVIEW

Observations and monitoring provide information about the way systems are changing over time.³⁴ Long-term datasets have allowed for important advancements in the understanding of the Earth system and will support future adaptation efforts in a number of ways. For instance, monitoring can help agencies decide when to begin actively adapting to specific impacts.³⁵ Long-term datasets may also aid in the establishment of “base cases” with which to compare adaptation improvements.

RESEARCH AND INFORMATION NEEDS

A number of agencies identified the need to build, improve, or expand their monitoring and surveillance activities. Some agencies are committed to developing advanced environmental monitoring techniques (e.g. DOC and USDA) while others are focused on interpreting monitoring and observational data to inform adaptation priorities (e.g. DHS and DOI). DOI also emphasized the important role of traditional ecological knowledge as a source of long-term observational knowledge.

CURRENT AND PLANNED ACTIVITIES

Improved Monitoring Capability

A number of departments within USDA noted the need for improved monitoring technology. The USDA National Agricultural Statistics Service (NASS) anticipates the need to continue to develop “the science and operational capacity of the NASS Remote Sensing

Box 12. North Pacific Climate Regimes and Ecosystem Productivity

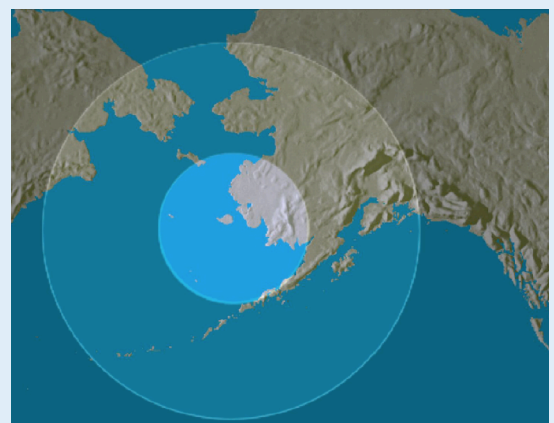
Background: Global models predict disproportionate climate change and variability at high latitudes. Because Alaskan fisheries represent about 50% of the U.S. commercial fishery, there is a strong need to understand how high latitude change will affect these fisheries. NOAA has responded to this concern by forming the North Pacific Climate Regimes and Ecosystem Productivity (NPCREP) program in 2004.

Adaptation Research and Information Need Addressed: This program addresses the need for data to inform decisions regarding *natural infrastructure* in the Arctic. NOAA also plans to add additional monitoring capacity, meeting the need for *improved monitoring capabilities* in the region.

Strategy: This program builds an understanding of how climate affects the eastern Bering Sea and Gulf of Alaska ecosystems. NPCREP utilizes a combination of retrospective, monitoring, process, and modeling studies to improve our understanding of climate-ecosystem relationships. NOAA is currently expanding their research efforts via the deployment of six biophysical moorings in the eastern Bering Sea and Chukchi Sea. NPCREP research is enabling the development of climate impact indicators, assessment tools, and models of regional climate change consequences. Part of the program also involves providing accessible data and tools for fishery managers.

Implications for Adaptation: Current deliverables from this program include the improvement of North Pacific stock assessments, a web-based data [portal](#), and contribution to the generation of indices and assessment tools to inform Total Allowable Catches for Alaskan marine fisheries. Relevant data products are made available to the North Pacific Fishery Management Council so they can adapt their management recommendations accordingly.

Image 10: Map of the NPCREP Study Area Focused on the Eastern Bering Sea



Resources:

DOC adaptation plan
www.st.nmfs.noaa.gov/st7/documents/NPCREP.pdf
www.pmel.noaa.gov/foci/NPCREP/

³⁴ U.S. Global Change Research Program. *Global Climate Change Impacts in the United States*. 2009:

Website: <http://downloads.globalchange.gov/usimpacts/pdfs/climate-impacts-report.pdf>

³⁵ The White House Council on Environmental Quality. *Progress Report of the Interagency Climate Change Adaptation Task Force: Recommended Actions in Support of a National Climate Change Adaptation Strategy*. 2010: p. 6. Website:

<http://www.whitehouse.gov/sites/default/files/microsites/ceq/Interagency-Climate-Change-Adaptation-Progress-Report.pdf>

Box 13. National Integrated Drought Information System

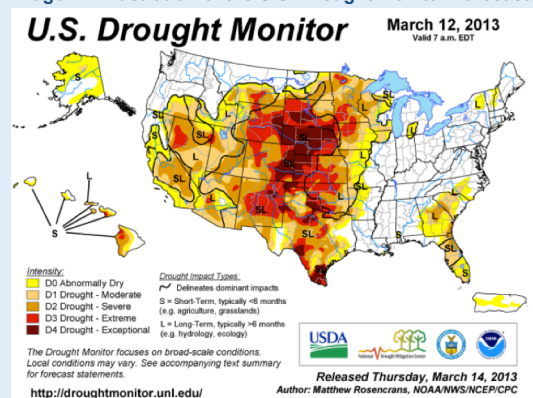
Background: In 2006, the National Integrated Drought Information System (NIDIS) was established by Congress to help support a more proactive response to drought. The web-based U.S. Drought Portal provides public access to NIDIS and to decision support tools like the Drought Early Warning System depicted below. The NIDIS implementation team also conducts workshops and meetings at the Federal, state, and local level to facilitate and inform stakeholders.

Adaptation Research and Information Need Addressed: NIDIS addresses the need for *tools and resources* by providing visualizations of drought, documents describing how to plan for drought, and programs that provide emergency assistance. In collaboration with NOAA's Drought Task Force, NIDIS is supporting the advancement of drought *monitoring* and prediction. NIDIS also supports *communication* via both K-12 educational material on the drought portal and webinars, briefings, forums, and conferences. The Regional Drought Early Warning System and region-specific webinars and workshops also meet a need for *region-specific information*.

Strategy: NIDIS is made possible by the collaboration of 16 different Federal agencies (USDA, DoC, DoE, DHS, DoI, DoT, USACE, EPA, FCA, FERC, IRS, USITC, NASA, NSF, SBA, and HHS) as well as State, Tribal, and local partners. There are several technical working groups that focus on various aspects of NIDIS (engaging community preparedness, public awareness and education, integrated monitoring and forecasting, interdisciplinary research and applications, and the U.S. Drought Portal).

Implications for Adaptation: NIDIS provides users with visual maps of drought intensity and temporal impact. Other links within the Portal provide resources to help stakeholders plan for drought and to provide emergency assistance. This information, in combination with the outreach activities conducted by NIDIS, will help the Nation form a more proactive response to drought.

Image 11: Illustration of the U.S. Drought Monitor Forecasts



Resource: <http://www.drought.gov/drought/content/products-current-drought-and-monitoring-drought-indicators/us-drought-monitor>

Program to support agency natural disaster response [and] produce time-sensitive monitoring and assessment data and products” (USDA ARS, p. 71). The USDA National Institute of Food and Agriculture (NIFA) stated the need to develop science-based methods to monitor climate impacts (USDA ARS, p. 79). DOC anticipated that others will look to them to “develop advanced measurements and standards for environmental monitoring and modeling to track and assess how physical, biological, and social processes have been and may be altered by climate change for use in decision making” (DOC, p. 11). As part of their 5-year strategic goals, DOC plans to “develop advanced measurements, tools, and standards for environmental monitoring” (DOC, p. 14). As far as international monitoring capabilities, the DOS Global Climate Observing System (GCOS) supports hands-on workshops to educate and train nations in establishing climate monitoring sites, as well as collecting, maintaining, and archiving data.

Improved Use of Monitoring and Records to Inform Adaptation Priorities

DOC’s NOAA has several very active environmental monitoring programs including their North Pacific Climate Regimes and Ecosystem Productivity Program (NPCREP, see Box 12), their Regional Climate Centers (RCC), Sentinel Site Cooperatives, and Center for Coastal Monitoring and Assessment. They plan to expand their North Pacific monitoring activities in response to the need for more information on changing conditions in the Arctic Ocean (DOC, p. 23). NOAA is also planning to invest more in its sentinel site program in order to increase their understanding of and improve their response to sea level change (DOC, p. 22). The USDA Forest Service (USFS) is working to implement a strategy that uses monitoring and assessment to incorporate climate change considerations in land management plans (FY12-14, USDA, p. 62, Appendix A). DOI also emphasized the need for monitoring as a part of effective adaptive management, suggesting that, in some cases, natural or cultural resource monitoring for climate change impacts may be easily mainstreamed into other pre-existing natural resource monitoring efforts. For example, “monitoring of changes in water tables can inform wetland and drainage issues as well as alteration of archaeological sites” (DOI, p. 6). DOI also emphasized the need to consider traditional ecological knowledge (TEK) and long-term observational information as data sources (DOI, p. 4). The National Integrated Drought Information System (NIDIS) is a great example of a program that takes advantage of monitoring datasets to produce

useful, accessible tools for relevant stakeholders. Among other things, NIDIS allows users to visualize drought intensity in order to better inform planning efforts (see Box 13).

Expand Species-specific Monitoring Capabilities

The need for species specific monitoring was also highlighted by a number of agencies. DOI noted the need to monitor the spread of invasive species (DOI, p. 5). Monitoring species distributions was also a concern for the USDA Animal and Plant Health Inspection Service (APHIS) who noted the need for surveillance and reporting on shifts in geographic distribution of wildlife, weeds, pests, and diseases. Similarly, as part of DHS's biosurveillance activities, they plan to "monitor how climate change impacts may exacerbate conditions that influence or contribute to bio-threats" (DHS, p. 20, *see the bio-threats Section 3 on the Human Health*).

Expand Monitoring of Human and Social Systems

The need to monitor social and human systems was also highlighted in agency plans. DOT plans to monitor and track employee health to better understand climate change impacts. DHS plans to "monitor societal and environmental trends to provide an 'early warning system' to manage risks to critical infrastructure" (DHS, p. 23). DOC mentioned the need to monitor the development of new export markets for green technologies in order to "help businesses capitalize on an increased demand for green technologies sparked by a changing climate" (DOC, p. 16-17). There is also a need to assess and monitor food insecure countries in order to define priorities for aid to other nation's agricultural sectors. The USDA Farm Services Agency (FSA) is addressing this need through their participation in the international working group known as Feed the Future.

OPPORTUNITIES FOR COLLABORATION

The interagency collaboration between both USGCRP and non-USGCRP agencies on observation and monitoring resources that can help inform and support adaptation at multiple scales would be ideal. Given the current and planned activities for this area, it would be of benefit for these agencies to collaborate or work with the USGCRP Observations IWG.

8. Decision Support Tools and Resources

OVERVIEW

Decision support tools help translate complex scientific information into formats that are more readily accessible and useful to adaptation planners and resource managers.³⁶ Tools that aid in communication, vulnerability assessment, and the formulation of adaptation options are needed to provide guidance for adaptation across the Federal Government.

Box 14. Coral Triangle Adaptation Toolkit

Background: As part of the USAID U.S. Support to the Coral Triangle Initiative (U.S. CTI) program, NOAA, the World Wildlife Foundation, the Conservation International, and others have collaborated to develop a climate change adaptation toolkit for coastal communities in the Coral Triangle (Indonesia, Malaysia, Philippines, Solomon Islands, Timor-Leste, and Papua New Guinea).

Adaptation Research and Information Need Addressed: The Coral Triangle Adaptation Toolkit addresses the need for both *regional climate information* and *tools and resources* to support climate change adaptation. The six tools included in the toolkit address many of the main research and information needs identified by the agency adaptation plans (see the *Implications for Adaptation* section for a description). Perhaps the most novel is Tool 6 (methods to monitor climate impacts and effectiveness of adaptation actions (benchmarks) supporting the need for *performance metrics*). Additionally, Tool 5 highlights adaptation options under six different themes that include *natural and built infrastructure*: river and estuarine management, mangrove and wetland management, coral reef management, fisheries management, community resilience, critical infrastructure protection, and coastal livelihoods.

Strategy: The Toolkit draws on a number of regional efforts, some of which were developed by the Micronesia Conservation Trust and the Pacific Island Managed and Protected Area Community. A Version 2 toolkit will be published with revisions based on lessons learned via implementation and Regional Exchange.

Implications for Adaptation: The Coral Triangle Adaptation Toolkit provides six tools that can be used together or separately to support adaptation planning, implementation, and assessment. The individual tools are:

- Tool 1: Benchmarks for Climate Adaptation in Coastal Communities
- Tool 2: Outreach Toolkit: Adapting to a Changing Climate
- Tool 3: Regional Climate Information Brief for the Coral Triangle
- Tool 4: Guide to Vulnerability Assessment and Local Early Action Planning
- Tool 5: Quick Reference Guide for Adaptation Options
- Tool 6: Methods to Monitor Climate Impacts and Effectiveness of Adaptation Actions

Image 12: Coral Triangle (Indonesia, Malaysia, Philippines, Solomon Islands, Timor-Leste, and Papua New Guinea)



Resource:

http://www.uscti.org/pages/Resources_ClimateChangeAdaptation_Page2.html

³⁶ White House Executive Office of the President. *The President's Climate Action Plan*. June 2013; p. 16. Website: <http://www.whitehouse.gov/sites/default/files/image/president27climateactionplan.pdf>

Decision support tools and resources are a critical bridge between the development of the information and its use. The collection and processing of information (science or otherwise) should be informed by the decision process(es) or questions that the information will be used for, and frequently this means designing the information collection so that it feeds into decision support tools and resources for agency decision making.

RESEARCH AND INFORMATION NEEDS

Adaptation Decision Support Tools and Resources

The need for adaptation tools and resources was reiterated across multiple agencies. In particular, agencies emphasized the need to identify and/or produce easily accessible, up-to-date scientific information for adaptation (DOE, DOD, DOI, VA, USACE). USACE also noted the need for two-way communication on actionable science needs. In other words, the potential users of actionable science products must communicate with actionable science producers about their needs just as the producers of actionable science products must communicate with the users to better explain the application of developed tools/products. Decision support tools were also in high demand, with at least eight agencies mentioning the need for outside collaboration and/or input to inform agency decision-making processes (DHS, RRB, GSA, HHS, Department of Treasury, DOD, DOJ, SBA). This need is answered in agency plans, ten of which mentioned the development of decision support tools (TVA, EPA, DOC, NASA, DOT, HHS, USDA, USPS, GSA, DOD). **Appendix C** lists some helpful adaptation tools and resources that were identified in the FY 2013 Agency Climate Change Adaptation Plans. These resources may help address the needs for decision support and easy access to up-to-date scientific information noted in several of the plans (see **Box 14** for an example adaptation toolkit for the Coral Triangle region).

CURRENT AND PLANNED RESOURCES

The USGCRP hosts a very basic Adaptation Resources web page that includes links to Federal publications, strategic plans, tools, and resources that can help support agency adaptation efforts. The page is a work in progress, and new resources will be added over time <http://www.globalchange.gov>. In the longer-term, the USGCRP plans to launch a prototype of a Global Change Information System (GCIS) that will include content from the Third National Climate Assessment, along with some additional tools and resources that may help address adaptation research and information needs noted in this analysis. In addition, the President's Climate Action Plan calls for "Providing a Toolkit for Climate Resilience."³⁷ This toolkit, which is currently under development, will provide a centralized access to data-driven resilience tools, services, and best practices. In addition, it will provide easy access to existing resources as well as new tools for adaptation.

OPPORTUNITIES FOR COLLABORATION

Within and across agencies, increased dialogue among the developers of scientific information and the end-users of such information can help promote the development of climate-adaptation tools and resources that are readily and intuitively useful. The ASIWG, the Agency Processes Workgroup of the Interagency Climate Change Adaptation Task Force, and the "community of practice" that is sponsored by that workgroup are potential venues through which agencies can cooperate more closely in this domain. Some examples of venues where collaboration is specifically fostered are the USGCRP ASIWG and the Agency Processes Workgroup of the Interagency Climate Change Adaptation Task Force and the wide Community of Practice sponsored by the Agency Processes Workgroup and open to all Federal agencies.

³⁷ White House Executive Office of the President. *President's Climate Action Plan*. 2013: p. 16. Website: <http://www.whitehouse.gov/sites/default/files/image/president27sclimateactionplan.pdf>

Conclusions and Next Steps

This report provides a basic overview of the common research and information needs expressed in 27 of the FY13 Agency Climate Change Adaptation Plans (see **Appendix B** for the list of agencies analyzed), along with some examples of current and planned research and information efforts to meet these needs. It is not comprehensive, but reflects many commonly cited and highly-relevant needs, challenges, and opportunities identified across FY 2013 Agency Climate Change Adaptation Plans. As noted in the summary section of this document, climate change adaptation research and information for ***built infrastructure, communication and training, and human health*** were among the most common themes noted by most of the plans.

The ASIWG hopes that the information provided in this analysis can help agencies and partners as they work to meet the goals outlined in the President's Climate Action Plan. Specifically, the information distilled in this document can help the USGCRP and its partners:

- Understand the most common research and information needs for adaptation as identified by agencies;
- Direct agencies to existing tools and resources that may help meet their needs;
- Initiate conversations between existing USGCRP Interagency Working Groups (IWGs) to collaborate on specific points for how best to meet these needs; and
- Inform future Federal research agendas related to climate change and adaptation actions.

Appendix A: Detailed List of FY13 Agency Climate Change Adaptation Research and Information Needs

1. BUILT INFRASTRUCTURE

- **Infrastructure Vulnerability Assessments**
 - Provide science to inform built infrastructure vulnerability assessments at relevant scales
 - Identify information regarding the timing, location, and extent of environmental change
 - Provide predictive capabilities at relevant scales
 - Identify models of sea level rise and flood risk
 - Understand multi-stressor impacts
 - Understand the interacting effects that pose adaptation challenges on built infrastructure
 - Understand climate change impacts on the supply of and demand for energy
 - Understand climate change impacts affect energy efficiency programs
 - Understand built infrastructure-economic linkages
- **Historic and Cultural Resources Vulnerability Assessments**
 - Assess vulnerabilities to historic and cultural resources
 - Implement a cultural resource monitoring systems to track environmental changes that may affect cultural resources
 - Understand climate change impacts on natural resources pertinent to native and indigenous communities
- **Economic Impact and Opportunity Assessments**
 - Illustrate local case studies in infrastructure adaptation practices
 - Identify metrics, tools, and standards to ensure structural and community resilience to climate change
 - Provide cost effective and performance based design tools that support infrastructure resilience to disaster
- **Infrastructure Adaptation Best Practices**
 - Incorporate adaptation-relevant sustainable building practices into existing standards
 - Provide guidance on how agency vulnerability analyses should influence planning and decision-making about built infrastructure
 - Identify critical facilities and infrastructure in order to appropriately prioritize adaptation actions

2. COMMUNICATION AND TRAINING

- **Government Employee Training**
 - Integrate climate change and disaster risk reduction into employee safety training materials
 - Improve disaster preparedness training
- **External Partner Training**
 - Inform communities, planners, and grantees on how to incorporate climate change adaptation into their infrastructure plans
 - Need to consider appropriate framing of adaptation training materials
- **Peer Exchange Programs and Workshops on Best Practices**
 - Training about the impacts of and responses to climate change
- **Online Curriculum and Training**
 - Climate change science training
 - Training in the use of decision support tools

- Training approaches that focus on awareness building
- Climate Change and Water Resources Training

3. HUMAN HEALTH

- **Heat Stress**
 - Assess how rising temperatures and potential increases in on-the-job hazards would affect agency employees
 - Identify policies that cover heat and storm awareness
- **Hazard-related Human Health Concerns**
 - Investigate on-the-job and disaster-related hazards
 - Improved understanding of the linkage between climate change impacts and mental health-related disorders
 - Improve mental health services that support the transition from short-term to long-term disaster recovery
- **The Role of Human Health in the Context of Multiple Stressors**
 - Understand the human health effects of multiple interacting stressors
 - Understand interactions between climate and the stratospheric ozone layer
 - Identify, to a greater level of detail, where (both within and outside of the U.S.) climate change-related health impacts are currently occurring or will likely occur
 - Consider environmental justice concerns when assessing vulnerability
- **Understanding and Responding to Climate Change-related “Bio Threats”**
 - Understand how climate change impacts may exacerbate conditions that influence or contribute to bio-threats
 - Understand the complex interactions between changes in the climate and specific infectious diseases
- **Climate Change and Air Quality Interactions (Indoor and Outdoor)**
 - Understand climate-related changes in indoor and outdoor air quality and the sources of indoor environmental contaminants
 - Develop cost-effective strategies to respond to changes in indoor and outdoor air quality

4. NATURAL RESOURCES

- **Coastal and Oceanic Research and Information to Inform Adaptation Actions**
 - Improve forecasting of ocean conditions and events
 - Improve data regarding severe storms and sea level rise
 - Improve understanding of the affect of climate change on fisheries
- **Arctic Research and Information to Inform Adaptation Actions**
 - Improve understanding of changes in the pattern and extent of both sea ice melt and permafrost thawing
- **Agricultural Research and Information to Inform Adaptation Actions**
 - Improve management strategies and technologies for monitoring and reducing livestock heat stress
 - Provide improved techniques to reduce agriculture-related water use
 - Develop genetically engineered crops that are better adapted to climate change
 - Enhance understanding of how climate is currently integrated into conservation activities
 - Improve understanding of how climate variability is already affecting agricultural and natural resource management
 - Understand the effects of climate change on pests and pathogens

- Improved pesticide management techniques
- **General Terrestrial Ecosystem Research, Information, and Management to Inform Adaptation Actions**
 - Increase understanding of forest, woodland, and grassland ecosystems
 - Improve understanding of how changes in climate may influence various cleanup remedy efforts
- **Species-based Research and Information to Inform Adaptation Actions**
 - Identify and reduce non-climate stressors that interact with climate change
 - Monitor invasive species
 - Understand and respond to species-specific impacts that threaten the livelihoods of native people and indigenous communities
- **Freshwater Research and Information to Inform Adaptation Actions**
 - Improve environmentally and economically sustainable water treatment options
 - Expand and encourage efficiency measures for water and energy use
 - Develop techniques for adjusting water management practices to respond to shifts in water supply
 - Understand and quantify the potential effects of climate change of water infrastructure
 - Strengthen and enhance water resource climate change vulnerability assessments
 - Identify flood risk and management best practices to prepare for hydrologic extremes
 - Basin-wide approaches to water resource management
 - Improved understanding of climate and water interactions

5. DISASTER RESPONSE

- **Modeling of Future Hazards and Natural Disasters**
 - Update models of flood events to consider climate change
 - Update modeling of natural disasters (such as HAZUS) to incorporate climate change-related shifts in the spatial patterns, frequency, and intensity of events
- **Assessment of Specific Actions to Improve Emergency Preparedness**
 - Methods to test infrastructural stability in the face of extreme weather
 - Methods to assess social preparedness to natural disaster impacts

6. REGIONAL CLIMATE INFORMATION AND MODELING

- **Improved Regional Modeling Capabilities and Access to Regional Climate Data**
 - Event forecasting
 - Scenario-based impact projections
 - Production of spatially explicit information that is regionally relevant (e.g., heat stress, air quality, flood, wildfire, or sea level rise risks)
 - Identify and explain issues associated with model resolution and regionalizing
 - Potential future climate change conditions by region
 - Potential future climate change impacts by region

7. OBSERVATIONS AND MONITORING

- **Improved Monitoring Capability**
 - Improve monitoring technology
 - Develop science-based methods for monitoring climate change impacts
- **Improved Use of Monitoring and Records to Inform Adaptation Priorities**
 - Monitoring as part of effective adaptive management
 - Consider traditional ecological knowledge and long-term observational information as data sources

- **Expand Species-specific Monitoring Capabilities**
 - Monitor the spread of invasive species
 - Surveillance and reporting on shifts in the geographic distribution of pests, and diseases
- **Expand Monitoring of Human and Social Systems**
 - Monitor and track employee health
 - Monitor the development of new export markets for green technologies
 - Monitor food insecure countries

8. *DECISION SUPPORT TOOLS AND RESOURCES*

- **Adaptation Decision Support Tools and Resources**
 - Outside collaboration/input to inform agency decision-making processes
 - Agencies planning to develop decision support tools

Appendix B: List of FY13 Agency Climate Change Adaptation Plans Reviewed



Commodity Futures Trading Commission



Department of Commerce (DOC)



Department of Defense (DoD)



Department of Energy (DOE)



Department of Education (DOEd)



Department of Health and Human Services (HHS)



Department of Homeland Security (DHS)



Department of the Interior (DOI)



Department of Justice (DOJ)



Department of Labor (DOL)



Department of State (DOS)



Department of Transportation (DOT)



Department of Treasury



General Services Administration (GSA)



National Aeronautics and Space Administration (NASA)



National Archives and Records Administration (NARA)



National Capital Planning Commission (NCPC)



Oversees Private Investment Corporation (OPIC)



Department of Health and Human Services (HHS)



Railroad Retirement Board (RRB)



Social Security Administration (SSA)



Tennessee Valley Authority (TVA)



U.S. Army Corps of Engineers (USACE)



U.S. Department of Agriculture (USDA)



U.S. Department of Housing and Urban Development (HUD)



U.S. Environmental Protection Agency (EPA)



U.S. Small Business Administration (SBA)

Appendix C: Useful Resources Identified in the FY13 Agency Climate Change Adaptation Plans

BUILT INFRASTRUCTURE

- DOT developed their grant program “Framework on Conducting Assessments of Transportation Infrastructure Vulnerable to Climate Change Effects” which has supported 5 pilot studies thus far to assess infrastructural vulnerabilities to climate change and test adaptation strategies.
- NOAA, USACE recently updated their sea level change guidance, summarized in Engineer Circular 1165-2-211 “Incorporating Sea-Level Change Considerations in Civil Works Programs” (USACE 2011). This information is available in a user-friendly format via Digital Coast’s web-based tool “Sea Level Rise and Coastal Flooding Viewer”
- The National Research Council’s Transportation Research Board has funded a research initiative by the National Cooperative Highway Research Program (NCHRP) 20-83(05) “Climate Change and Highway Infrastructure: Impacts and Adaptation Approaches.” The project aims to create a guidebook for planners, National Environmental Policy Act (NEPA) practitioners, designers, asset managers, and operators that will describe how adaptation can be incorporated into different stages of transportation decision-making (planning, construction, and operations).
- Providing accurate and timely weather information for aviation decision makers through the NextGen Network Enabled Weather (NNEW), a network service based infrastructure that will provide quick, easy, and cost effective access to weather information.

COMMUNICATIONS AND TRAINING

- DOT’s FHWA peer exchange workshops have been successful in providing a forum for State representatives to discuss effective approaches to climate change adaptation.
- USDA’s NIFA support to the Extension Disaster Education Network (EDEN) which links Extension educators across the county, enabling resource sharing to reduce the impact of disasters.
- USDA hopes to establish regional farming networks to encourage the exchange of region-relevant information. The “Why do we care about climate change” online curriculum developed by USDA provides a more general resource for both employees and stakeholders on the impacts of climate change on agriculture and natural resources.

CLIMATE CHANGE AND HUMAN HEALTH

- The 2010 NIH-led interdepartmental Workgroup white paper “A Human Health Perspective on Climate Change” which identifies knowledge gaps related to the effects of climate change on human health (IWGCC 2010).
- The CDC’s “Climate Change and Extreme Heat Events” publication describes extreme heat events, how an extreme heat event threatens public health, and how to prepare for and respond to such an event. It explains how the frequency, duration, and severity of extreme heat events are increasing as a result of climate change, and includes links to local programs and real-world examples from across the country.
- The EPA, CDC, NOAA, National Weather Service (NWS), and DHS partnered to support the development of the “Excessive Heat Events Guidebook” which may serve as a resource for agencies who are interested in assessing the vulnerability of their employees to heat stress.
- The CDC Climate-Ready States and Cities Initiative is currently working with eight States and two cities to assess, plan, and implement health-related climate change adaptation programs.
- The CDC Building Resilience Against Climate Effects (BRACE) framework provides funding and a five step series of actions for State, territorial, and Tribal health departments to take in creating climate change adaptation plans.
- DOEd is planning to address the need for bio-threat response by developing infectious disease plans under the Readiness and Emergency Management for Schools (REMS) program.
- USGCRP’s resources on climate change and human health along with the interagency Climate Change and Human Health Group (CCHHG)
- A new Metadata Access Tool for Climate and Health (MATCH) serves as an online clearinghouse of publicly available Federal metadata that pertains to climate and health.

NATURAL RESOURCES

- Agroclimate is a web-based tool produced by the Southeast Climate Consortium that provides seasonal climate information to farmers in order to inform farm management decisions.

- The National Fish, Wildlife, and Plants Climate Adaptation Strategy is a first-of-its-kind document that provides a blueprint for fish, wildlife, and plant adaptation action at Federal, State, Tribal, and local levels. In addition, a recent webinar describing the strategy can be found online.
- Oregon State University's Parameter-elevation Regressions on Independent Slopes Model (PRISM) Climate Group is partnering with USDA to build a Climate and Weather web portal that will be used by risk management and crop insurance providers and can also be used by producers to make planting and production decisions.
- USDA's Agricultural Research Service (ARS) and NOAA's National Weather Service have partnered to develop a website for livestock producers that provides daily and 7-day heat stress forecasts for the U.S. (data is broken out into six regions).
- USDA's U.S. Forest Service (USFS) has a Watershed Condition Framework and Terrestrial Condition Framework that provide "processes and tools for characterizing and prioritizing watersheds and landscapes for restoration and developing adaptation strategies" (USDA, p. 63, Appendix A).

REGIONAL CLIMATE INFORMATION AND MODELING

- The Coral Triangle Adaptation Toolkit is a series of six region-specific adaptation tools for the coastal communities in Indonesia, Malaysia, the Philippines, the Solomon Islands, Timor-Leste, and Papua New Guinea.
- NOAA's six Regional Climate Centers (RCC) are a Federal-State cooperative that produce and deliver useful regional climate data (including regional climate outlook products) for the Western, High Plains, Midwestern, Southern, Southeast and Northeast regions.
- NOAA also has the Regional Integrated Sciences and Assessments (RISA) Program that supports the development of adaptation information and tools in 11 different regions throughout the U.S.
- DoD is engaged in two Federal-state partnerships; the Western Regional Partnership broadly aims to improve regional sustainability whereas the Southeast Regional Partnership for Planning and Sustainability is particularly active in supporting projects that aim to improve understanding of regional climate change impacts and adaptation strategies.
- DOT's Gulf Coast Study represents another regional effort that examines how changes in climate over the next 50-100 years could affect transportation systems in the U.S. Gulf Coast region. Phase I of the study was completed in 2008 and Phase II is ongoing.
- On a smaller scale, Secretarial Order No. 3289 established the DOI supported Landscape Conservation Cooperative (LCC), a network of 22 landscape-scale public-private partnerships across the country.
- EPA has links to webinar presentation slides, transcripts, and podcasts that may be useful to regional decision makers. USGCRP is planning to produce short summaries of the lengthy Regional Climate Scenarios that will be translated into terms that are understood by multiple users of the scenarios.
- Other plans to expand the accessibility of regional climate information include the DOI's plans to expand their National Climate Change and Wildlife Center to include a series of eight regional Climate Science Centers (CSC).

OBSERVATIONS AND MONITORING

- The National Integrated Drought Information System (NIDIS) is a tool that allows users to visualize drought intensity and provides resources for proactive drought planning.
- As far as international monitoring capabilities, the DOS Global Climate Observing System (GCOS) supports hands-on workshops that educate and train nations in establishing climate monitoring sites, as well as collecting, maintaining, and archiving data.
- Global models predict disproportionate climate change and variability at high latitudes. Because Alaskan fisheries represent about 50% of the U.S. commercial fishery, there is a strong need to understand how high latitude change will affect these fisheries. NOAA has responded to this concern by forming the North Pacific Climate Regimes and Ecosystem Productivity (NPCREP) program.